

Daily report

23-05-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ α : the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ K : the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to datapoints. We also discuss a specific issue every day.

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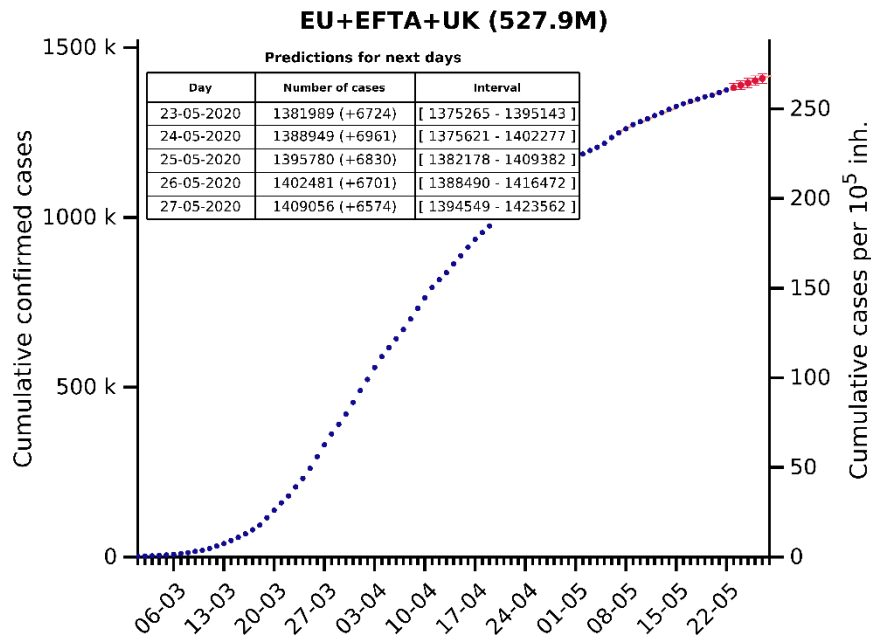
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(0) Executive summary – Dashboard

Weekend short version

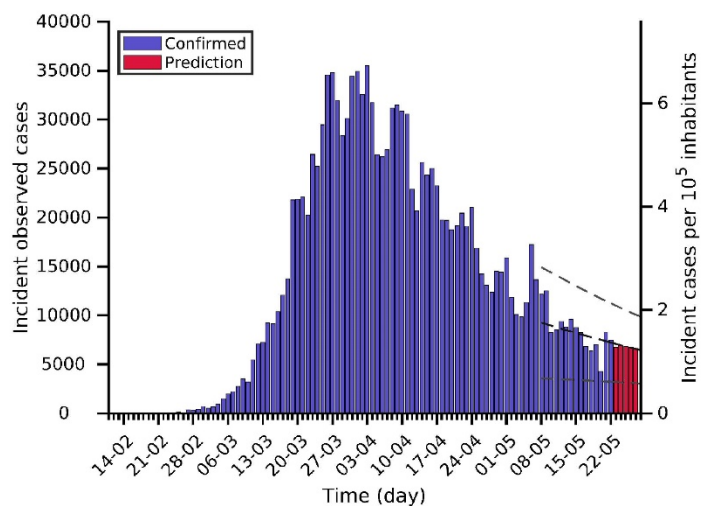
Attack rate and short-term predictions in EU+EFTA+UK

Short-term predictions, based on last 15 points with increased weight on last 3:



Highlights and/or warnings

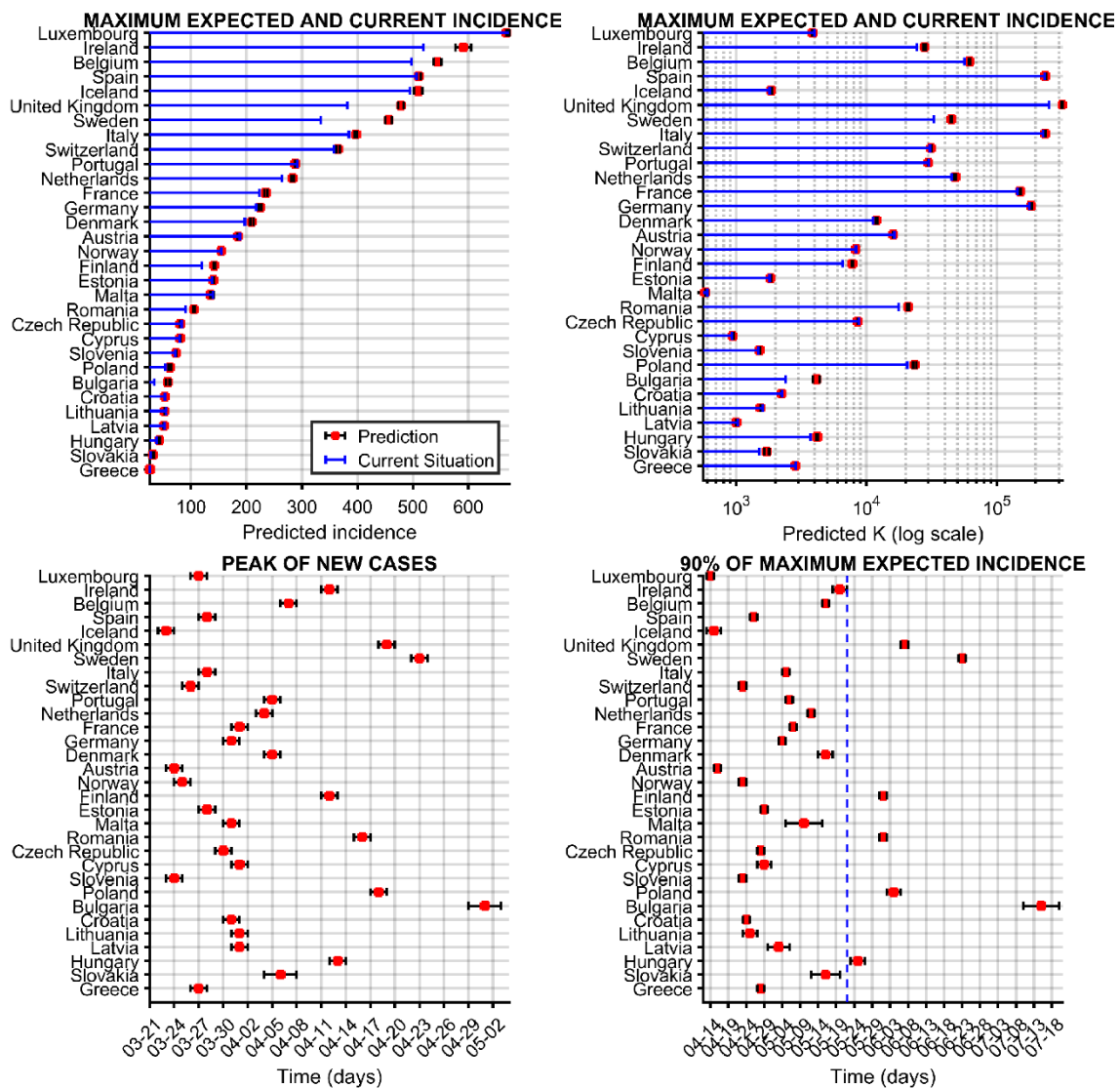
- UE+EFTA+UK new cases are shown in the figure. They are currently at the level of 7,400.
- Increase in new cases of last 2 days is driven by Spain (1,800 new cases yesterday) and UK (3,300 new cases today).
- All countries maintain trends from previous days.
- There are several countries at $p_7 \geq 1$ but with low A_{14} (see table). These cases are not worrying if a significant increase is not observed in the next days.
- We start including information of other countries in this Executive summary.



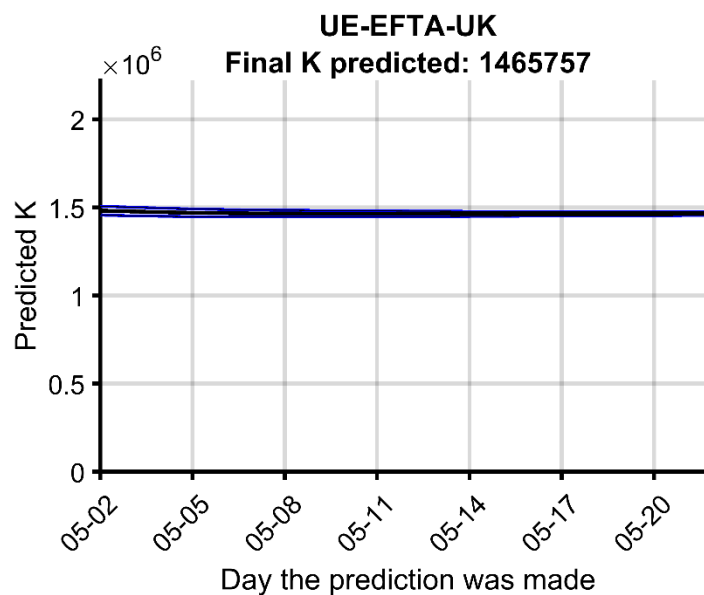
Long-term predictions

Long-term predictions, evaluated with the **whole historical series**. See figure in the next page. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current

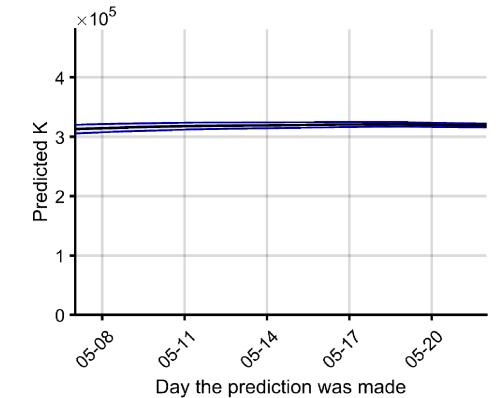
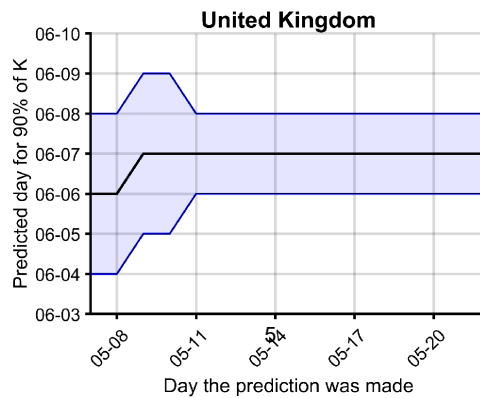
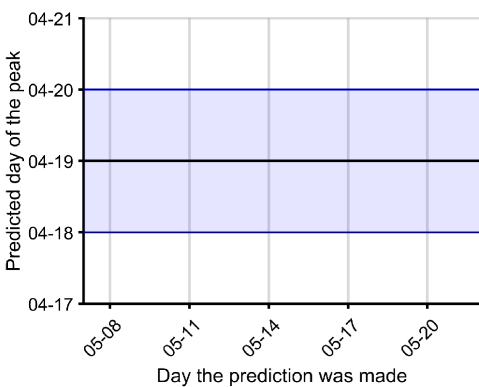
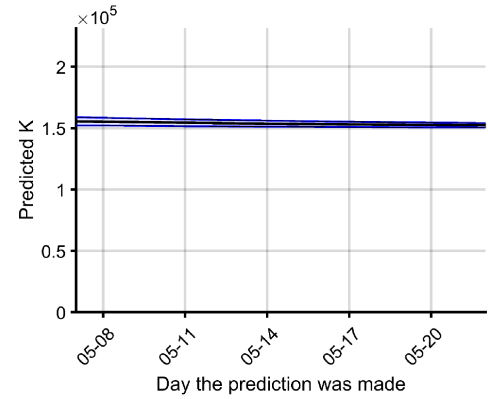
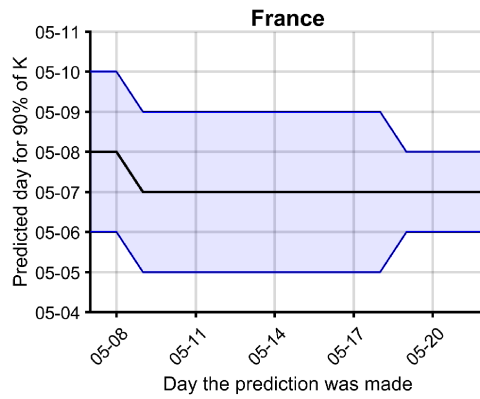
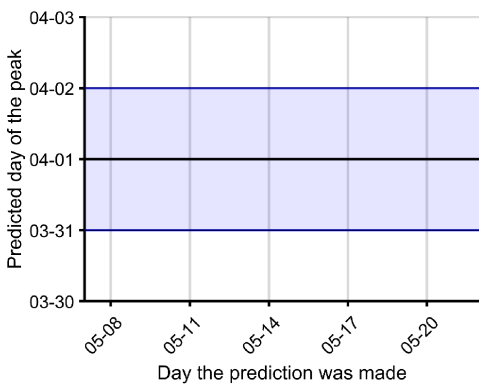
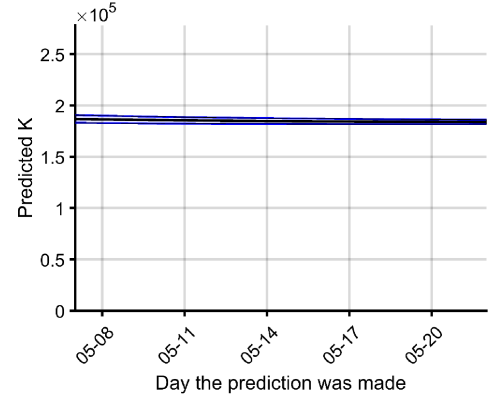
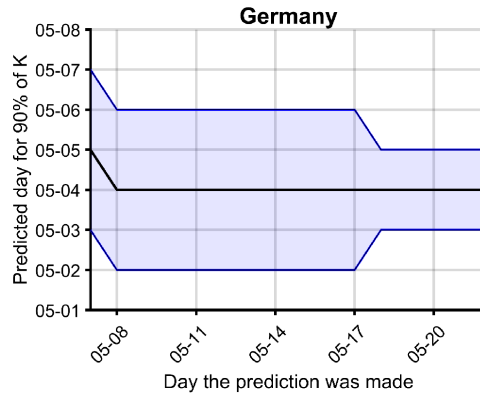
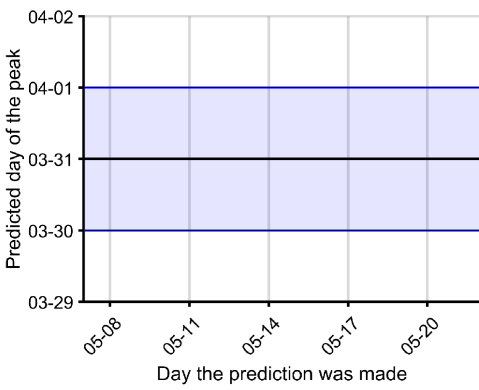
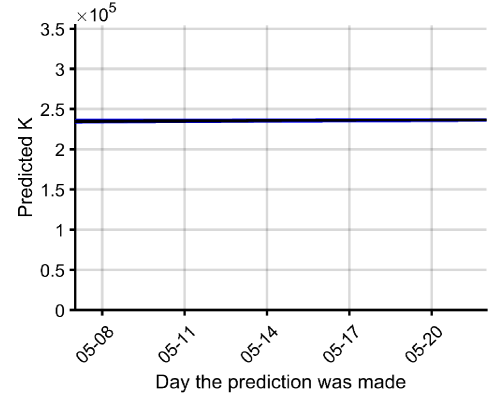
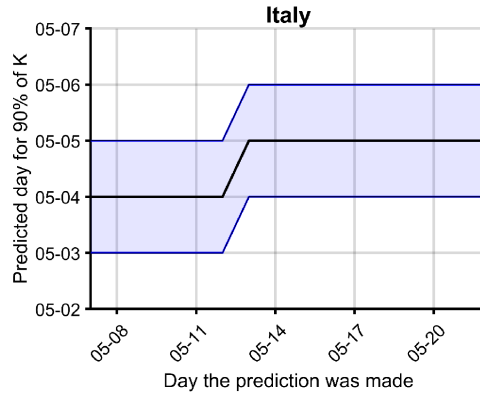
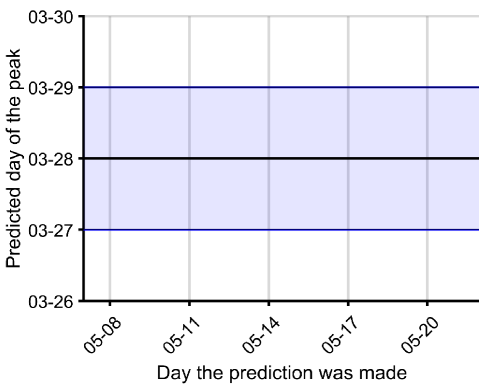
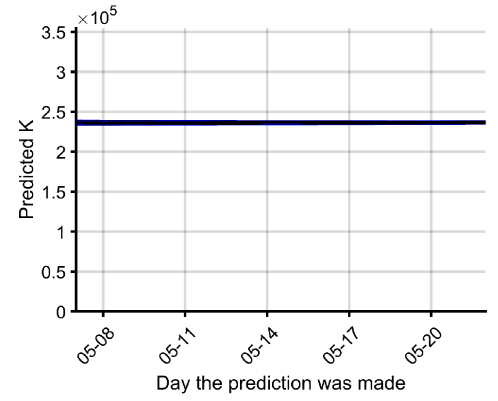
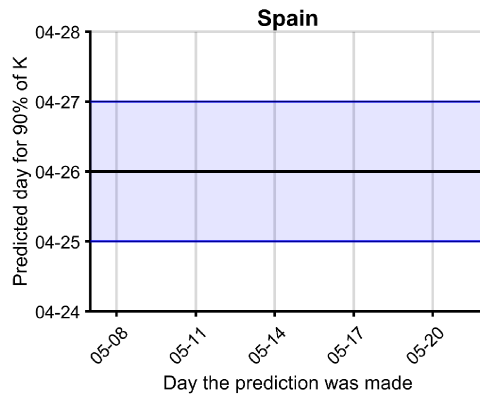
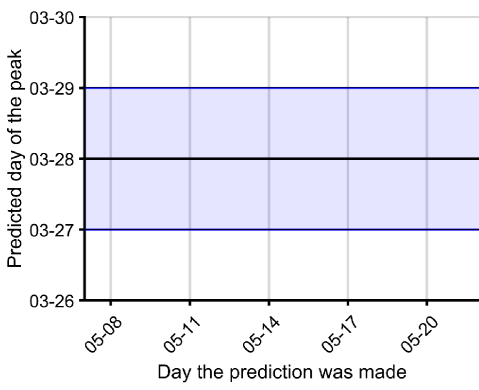
situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.



Final expected K for UE+EFTA+UK. Evolution of predicted K with time, where convergence to best estimate is seen. Last prediction is numerically shown.



2020-05-22



Situation and trends per country

Maps. The map in the left shows current A_{14} . The map in the right shows current EPG .

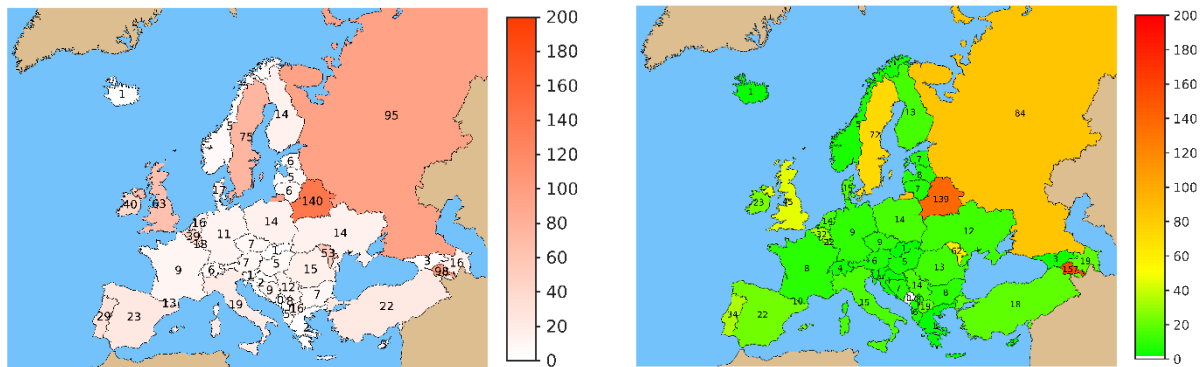


Table of current situation in EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

Country	Reported data								Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulative deaths	Mortality /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10 ⁵ inh.	$\rho_7^{(1)}$	$EPG_{REP}^{(2)}$	$EPG_{EST}^{(3)}$
United Kingdom	254,195	382.6	36,393	54.8	42,831	64.5	638,931	941.2	0.71	46	673
Spain	234,824	506.7	28,628	61.8	10,863	23.4	126,342	268.7	0.96	23	258
Italy	228,658	384.8	32,616	54.9	11,473	19.3	167,335	276.8	0.77	15	214
Germany	177,850	217.1	8,216	10.0	9,299	11.4	46,547	55.6	0.85	10	47
France	144,566	223.4	28,289	43.7	6,145	9.5	124,473	190.7	0.88	8	167
Belgium	56,511	497.5	9,212	81.1	4,500	39.6	75,678	653.0	0.82	32	534
Netherlands	44,888	264.2	5,788	34.1	2,795	16.5	37,010	216.0	0.84	14	181
Sweden	32,809	333.5	3,925	39.9	7,544	76.7	100,214	992.3	0.96	74	957
Switzerland	30,624	357.3	1,637	19.1	500	5.8	2,766	32.0	0.73	4	23
Portugal	30,200	291.2	1,289	12.4	2,932	28.3	13,774	135.1	1.17	33	158
Ireland	24,506	518.5	1,592	33.7	1,965	41.6	12,908	261.4	0.58	24	151
Poland	20,619	53.9	982	2.6	5,253	13.7	28,754	76.0	1.01	14	77
Romania	17,712	89.6	1,159	5.9	2,901	14.7	20,251	105.3	0.85	12	89
Austria	16,361	187.8	635	7.3	626	7.2	2,547	28.3	0.89	6	25
Denmark	11,230	196.6	561	9.8	1,012	17.7	5,214	90.0	0.86	15	78
Czech Republic	8,813	83.1	312	2.9	736	6.9	2,848	26.6	1.25	9	33
Norway	8,309	154.8	235	4.4	275	5.1	799	14.7	0.95	5	14
Finland	6,537	118.8	306	5.6	799	14.5	4,144	74.8	0.93	14	70
Luxembourg	3,981	691.1	109	18.9	110	19.1	312	49.9	1.23	23	61
Hungary	3,713	38.1	482	4.9	500	5.1	6,994	72.4	1.04	5	75
Greece	2,873	25.7	169	1.5	182	1.6	1,093	10.5	0.81	1	9
Bulgaria	2,408	33.8	126	1.8	497	7.0	3,000	43.2	1.17	8	50
Croatia	2,243	53.2	99	2.3	82	1.9	0	0.0	0.65	1	NA
Estonia	1,807	137.7	64	4.9	82	6.3	0	0.0	1.14	7	NA
Iceland	1,803	495.0	10	2.7	2	0.5	0	0.0	0.43	0	NA
Lithuania	1,604	55.2	61	2.1	168	5.8	0	0.0	1.05	6	NA
Slovakia	1,503	27.6	28	0.5	48	0.9	0	0.0	1.14	1	NA
Slovenia	1,478	71.1	106	5.1	28	1.3	196	9.4	0.95	1	9
Latvia	1,030	52.3	22	1.1	102	5.2	0	0.0	1.45	8	NA
Cyprus	927	79.2	17	1.5	36	3.1	0	0.0	0.84	3	NA
Malta	600	139.9	6	1.4	111	25.9	0	0.0	NA	NA	NA
Liechtenstein	83	215.3	1	2.6	0	0.0	0	0.0	NA	NA	NA
Scale											
Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	100	1000
Best	Best	Best	Best	Best	Best	Best	Best	Best	0.0	0	0

⁽¹⁾ ρ_7 is the average of 7 consecutive ρ , but can still fluctuate. ^(2,3) EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10⁵ inhabitants (i.e. density of cases) by ρ_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10⁵ inhabitants by ρ_7 .

Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

Situation and trends in other countries

Table of current situation in a sample of non-EU countries. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables. EPG_{REP} and EPG_{EST} **cannot be compared between them** because scales are different, but can be independently used for estimating risk of countries according to reported or estimated real situation, respectively.

Country	Reported data								Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulative deaths	Mortality /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate /10 ⁵ inh.	$p_7^{(1)}$	EPG _{REP} ⁽²⁾	EPG _{EST} ⁽³⁾
United States of America	1,601,434	483.8	96,007	29.0	317,505	95.9	2,086,515	630.4	1.02	98	641
Brazil	330,890	155.7	21,048	9.9	185,562	87.3	1,524,299	717.1	1.46	128	1,048
Russia	326,448	223.7	3,249	2.2	138,589	95.0	154,888	106.1	0.89	84	94
Iran	131,652	156.7	7,300	8.7	26,961	32.1	160,776	191.4	1.20	39	230
India	125,101	9.2	3,720	0.3	65,439	4.8	239,966	17.7	1.32	6	23
Peru	111,698	338.8	3,244	9.8	49,851	151.2	169,878	515.2	1.23	186	635
Canada	82,469	218.5	6,250	16.6	16,035	42.5	146,426	388.0	0.96	41	374
Saudi Arabia	67,719	194.5	364	1.0	32,287	92.7	NA	NA	1.25	116	NA
Mexico	62,527	48.5	6,989	5.4	31,005	24.0	460,198	356.9	1.24	30	444
Chile	61,857	323.6	630	3.3	35,885	187.7	82,847	433.4	1.47	276	637
Pakistan	52,437	23.7	1,101	0.5	24,963	11.3	62,273	28.2	1.19	13	34
Qatar	40,481	1,405.1	19	0.7	20,280	703.9	NA	NA	1.11	783	NA
Ecuador	35,828	203.1	3,056	17.3	7,010	39.7	67,557	382.9	1.71	68	653
Belarus	34,303	363.0	190	2.0	13,202	139.7	NA	NA	0.99	139	NA
Argentina	10,636	23.5	433	1.0	5,038	11.1	32,143	71.1	1.54	17	110

Scale										
Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	100
Best	Best	Best	Best	Best	Best	Best	Best	Best	0.0	0

⁽¹⁾ p_7 is the average of 7 consecutive p , but can still fluctuate. ^(2,3) EPG stands for Effective Growth Potential. EPG_{REP} is obtained by multiplying attack rate of last 14 days per 10⁵ inhabitants (i.e. density of cases) by p_7 (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG_{EST} is obtained by multiplying estimated real attack rate of last 14 days per 10⁵ inhabitants by p_7 .

Disclaimer: estimated active cases and estimated 14-day attack rate are assessed by assuming a lethality of 1 % (see report from 20 to 24 April, #37-41). This value can change in countries where suspicious deaths are reported as well (real values would be lower) and in countries where incidence among elderly people was minor (real values would be higher).

Time indicators by country

This tables summarize a few time indicators for each country: time since 50 cases were reported, time interval between an attack rate of $1/10^5$ inhabitants and an attack rate of $10/10^5$ inhabitants, and time interval between attack rates of 10 to 100 per 10^5 inhabitants (only for countries that have overtaken this threshold).

EU+EFTA+UK countries

Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Italy	90	11	16
Germany	84	12	17
Spain	83	8	12
France	83	10	20
United Kingdom	79	10	12
Switzerland	78	8	11
Sweden	78	10	28
Norway	78	2	7
Netherlands	78	11	20
Belgium	78	11	14
Austria	76	10	14
Denmark	75	4	30
Iceland	72	5	15
Greece	72	18	NA
Finland	72	12	46
Czech Republic	72	11	NA
Slovenia	71	6	NA
Portugal	71	9	15
Romania	70	15	NA
Poland	70	17	NA
Ireland	70	8	18
Estonia	70	5	30
Luxembourg	67	6	7
Slovakia	66	24	NA
Croatia	65	12	NA
Bulgaria	65	30	NA
Latvia	64	12	NA
Hungary	64	20	NA
Lithuania	63	9	NA
Malta	62	9	35
Cyprus	61	12	NA

Other countries

Countries	Days since the first 100 cases	Time interval between 1 and 10 cases / 10^5 inh. (days)	Time interval between 10 and 100 cases / 10^5 inh. (days)
Iran	87	11	42
United States of America	82	8	15
Canada	73	11	27
Qatar	73	3	31
Brazil	70	20	34
Saudi Arabia	69	21	29
Chile	68	13	36
Pakistan	68	35	NA
India	68	NA	NA
Russia	67	15	24
Peru	67	18	22
Ecuador	67	10	30
Mexico	66	25	NA
Argentina	65	39	NA
Belarus	54	10	18

Situation, trends and long-term predictions in Italian regions¹

Situation and trends

Country	Reported data								Indexes		
	Cumulative cases	Attack rate / 10^5 inh.	Cumulative deaths	Mortality / 10^5 inh.	Active cases (last 14 days)	14-day attack rate / 10^5 inh.	Estimated active cases (last 14 days)	Estimated 14-day attack rate / 10^5 inh.	$p_7^{(1)}$	EPG _{REP} ⁽²⁾	EPG _{EST} ⁽³⁾
Lombardia	86,825	864.6	15,840	157.7	5,600	55.8	105,378	1,047.4	0.76	42	793
Piemonte	30,137	691.8	3,771	86.6	1,588	36.5	20,499	470.6	0.83	30	391
Emilia Romagna	27,513	617.0	4,047	90.8	794	17.8	11,983	268.7	0.82	15	220
Veneto	19,069	388.7	1,865	38.0	398	8.1	4,014	81.8	0.73	6	59
Toscana	10,047	269.4	1,011	27.1	302	8.1	3,115	83.5	0.89	7	74
Liguria	9,427	607.9	1,414	91.2	689	44.4	10,434	672.7	0.93	41	624
Lazio	7,607	129.4	676	11.5	474	8.1	4,477	76.2	0.96	8	73
Marche	6,701	439.3	993	65.1	208	13.6	3,037	199.2	0.52	7	103
Campania	4,744	81.8	404	7.0	168	2.9	1,453	25.0	0.86	2	21
Puglia	4,448	110.4	486	12.1	162	4.0	1,804	44.8	1.11	4	50
Trento	4,395	409.9	456	42.5	103	9.6	1,089	202.4	1.69	16	343
Sicilia	3,421	68.4	269	5.4	108	2.2	854	17.1	0.73	2	12
Friuli Venezia Giulia	3,233	266.0	327	26.9	109	9.0	1,127	92.7	0.88	8	81
Abruzzo	3,221	245.6	394	30.0	135	10.3	1,643	125.2	0.86	9	108
Bolzano	2,590	2,410.7	291	270.9	23	21.4	284	54.5	1.03	22	56
Umbria	1,430	162.1	74	8.4	23	2.6	0	0.0	0.84	2	NA
Sardegna	1,356	82.7	129	7.9	22	1.3	208	12.7	0.60	1	8
Valle d'Aosta	1,177	937.1	143	113.8	25	19.9	291	231.0	0.44	9	103
Calabria	1,157	59.4	96	4.9	28	1.4	0	0.0	0.56	1	NA
Molise	431	141.0	22	7.2	84	27.5	0	0.0	0.43	12	NA
Basilicata	398	70.7	27	4.8	16	2.8	0	0.0	0.98	3	NA

Scale										
Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	100
Best	Best	Best	Best	Best	Best	Best	Best	Best	0.0	0

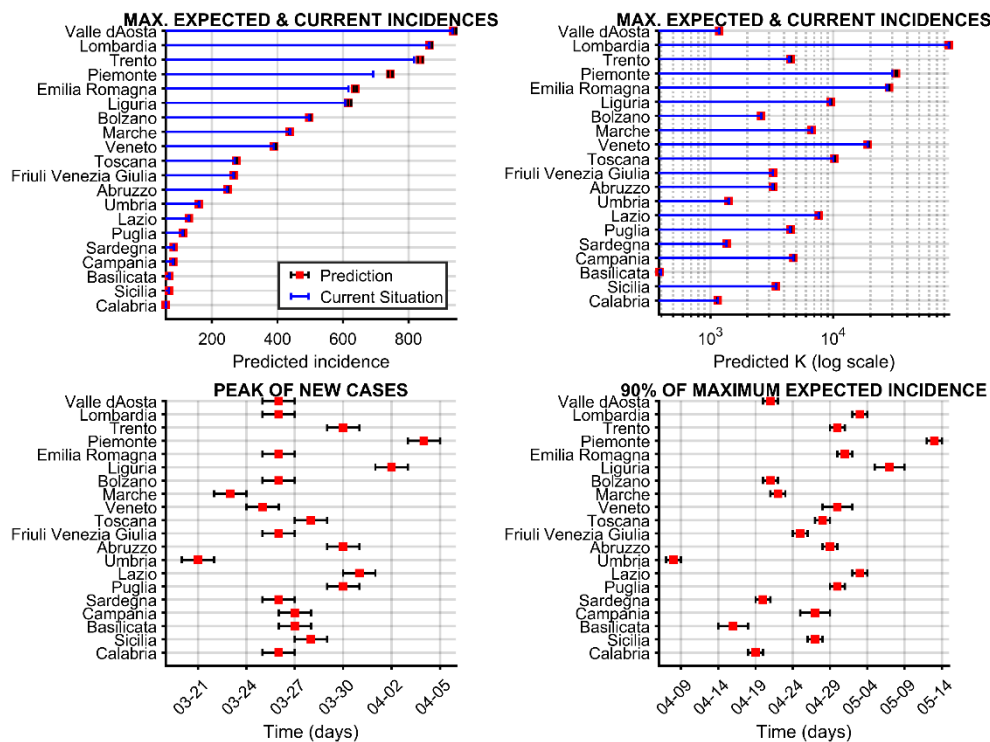
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¹ **Spain:** Historical series have not been updated. Therefore, regional analysis is not shown

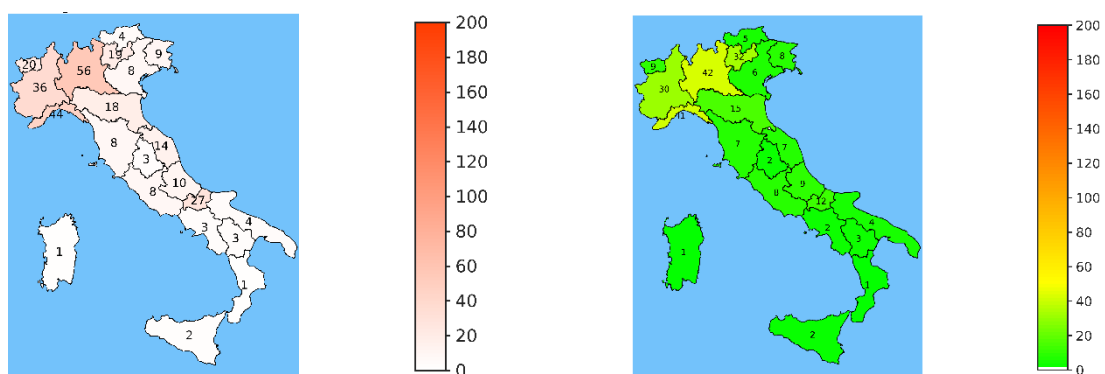
Long-term predictions

Evaluated with the **whole historical series**. See figure in the next page. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date.

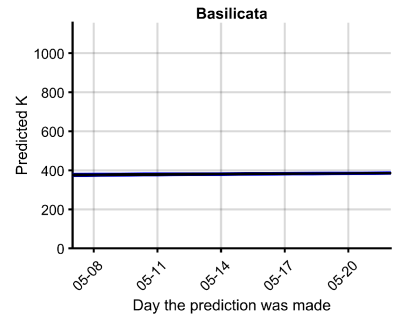
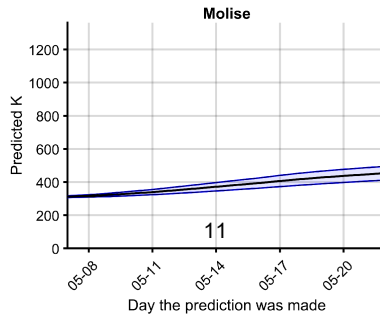
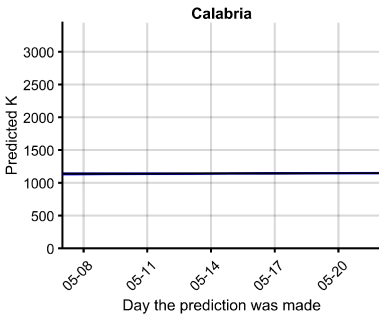
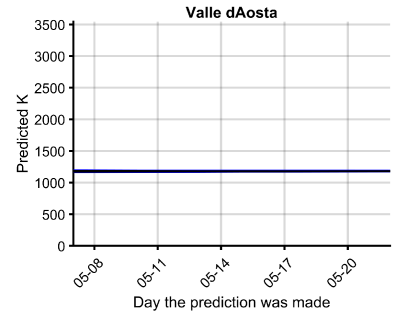
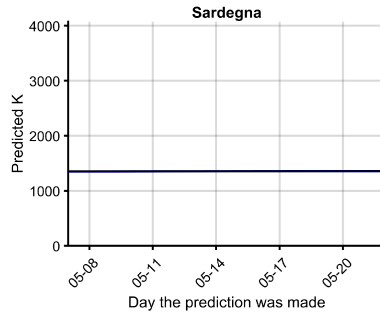
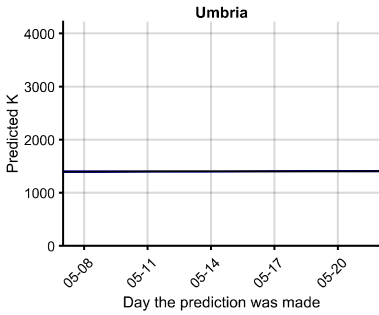
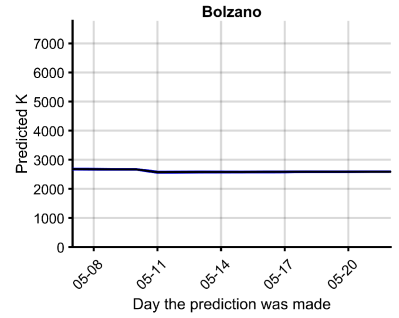
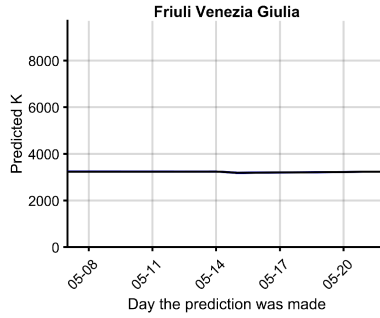
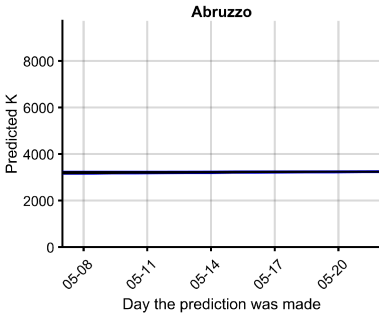
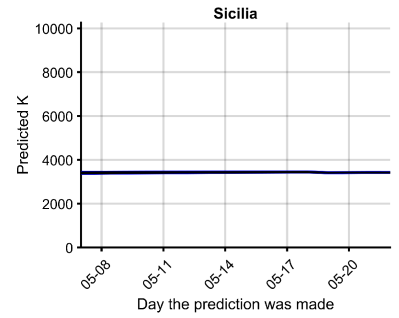
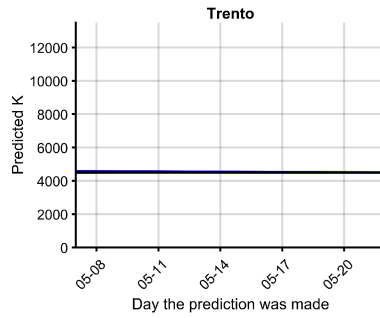
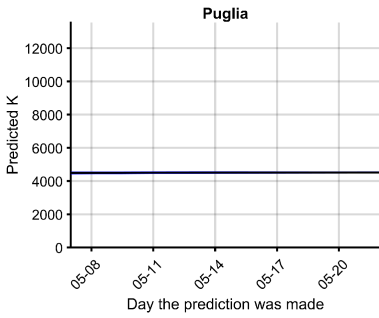
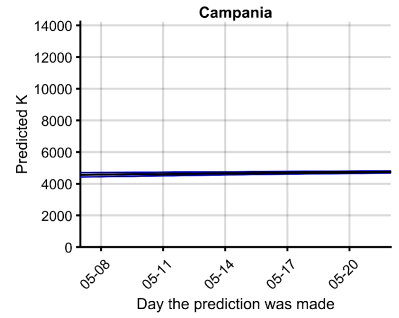
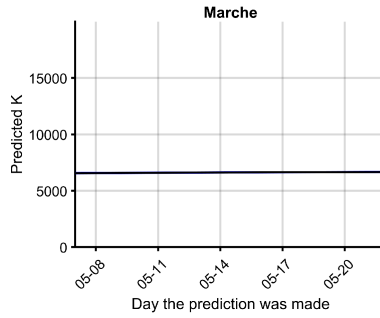
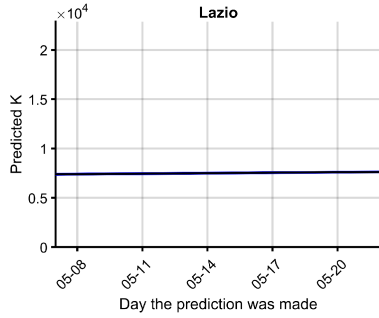
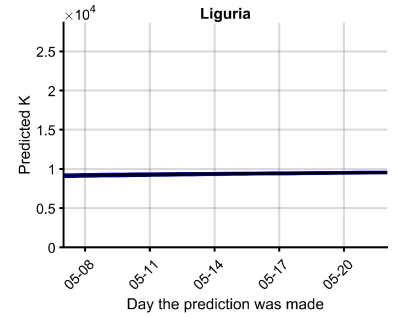
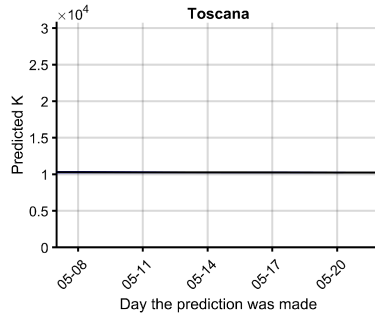
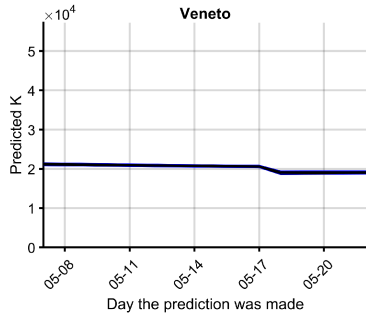
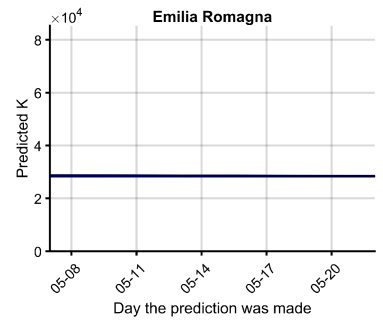
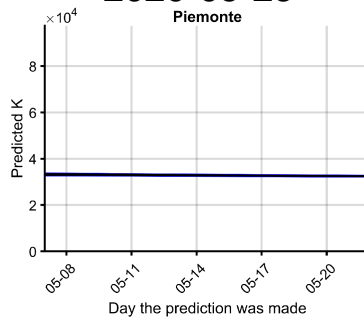
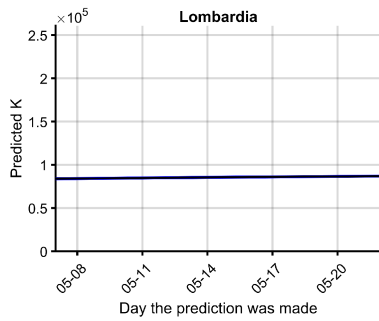


Maps

The map in the left shows current A_{14} . The map in the right shows current EPG.



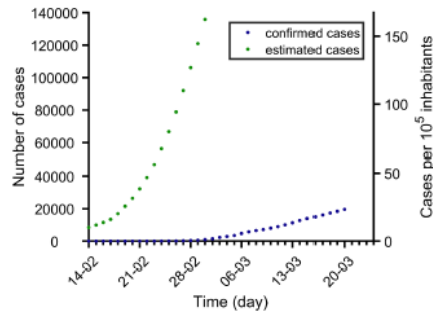
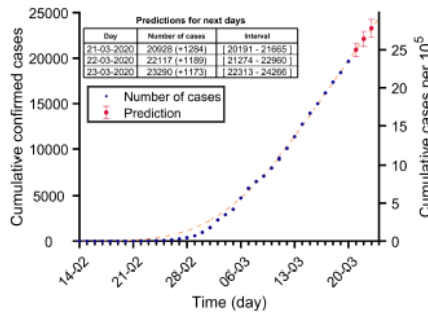
2020-05-23



Legend: Countries' reports details

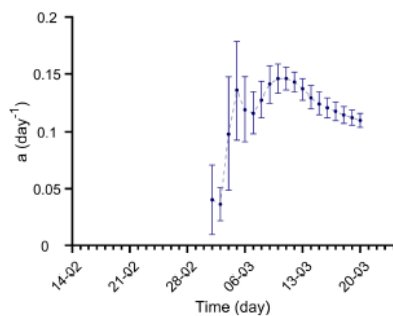
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence: $23/10^5$

Confirmed cases:
data (blue),
model fitted
(dashed line),
predictions (red
points and table)

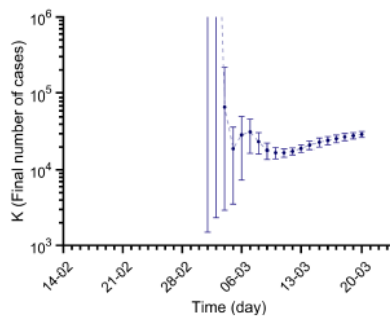


Estimated
cases using
death rate (see
Methods)

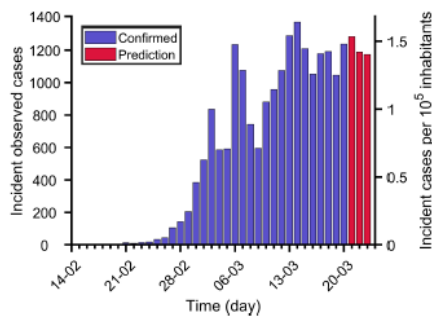
Fitted a value
using points
prior to each
date



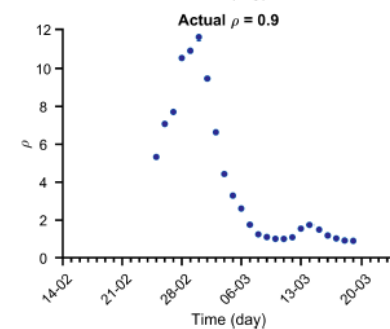
Fitted K value
using points
prior to each
date



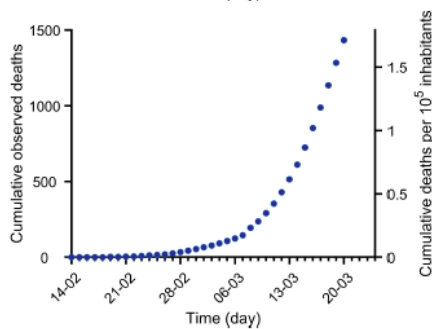
Reported
and
predicted
new cases



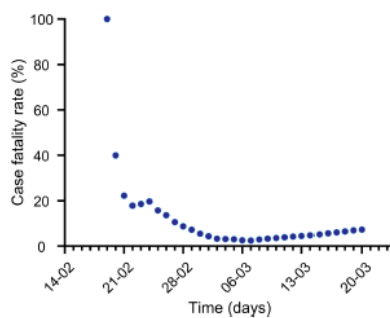
Evolution of ρ , a
parameter related
with Reproduction
number (see
Methods)



Reported
deaths

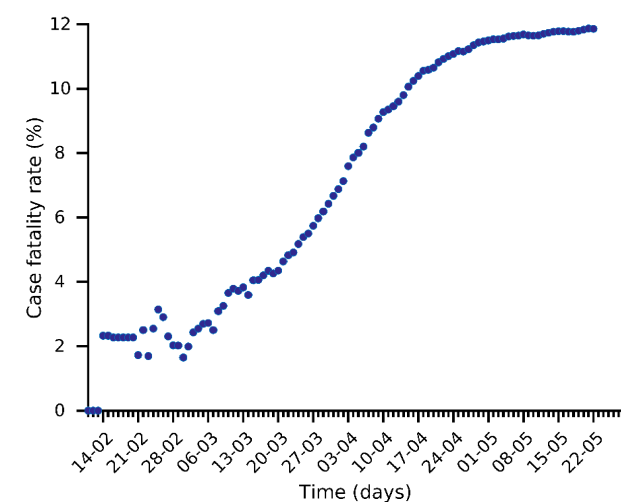
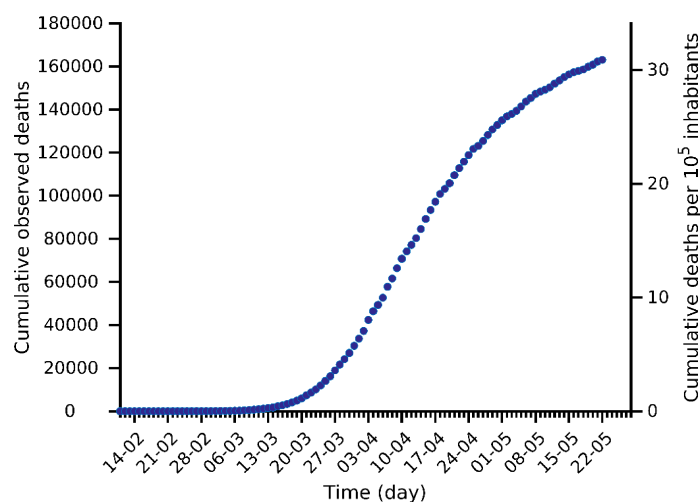
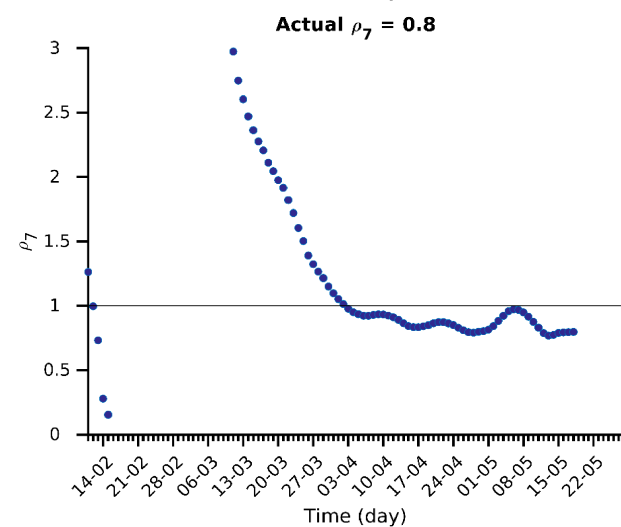
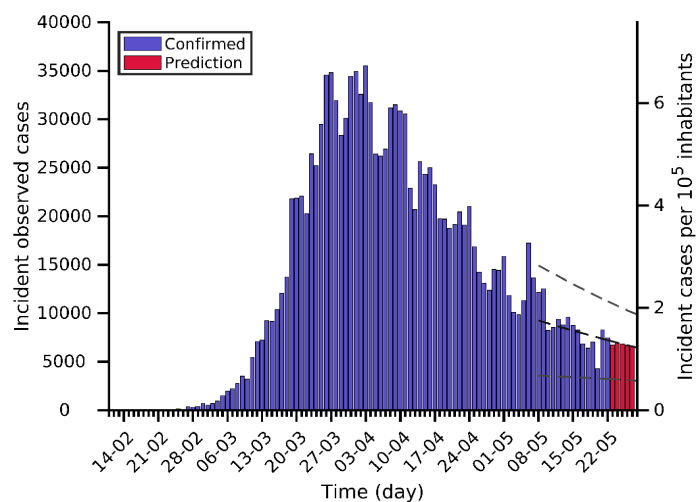
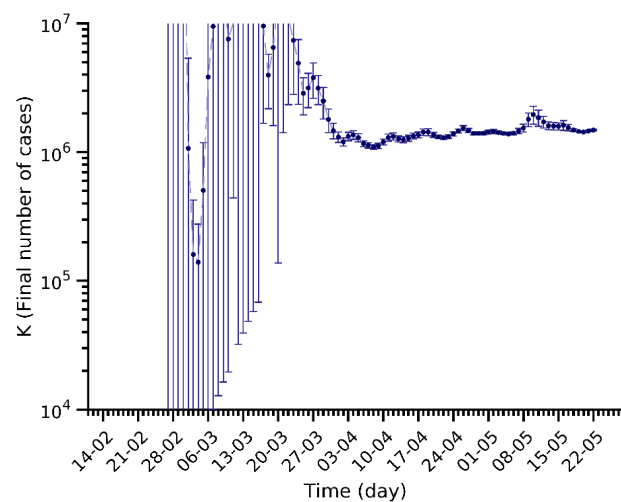
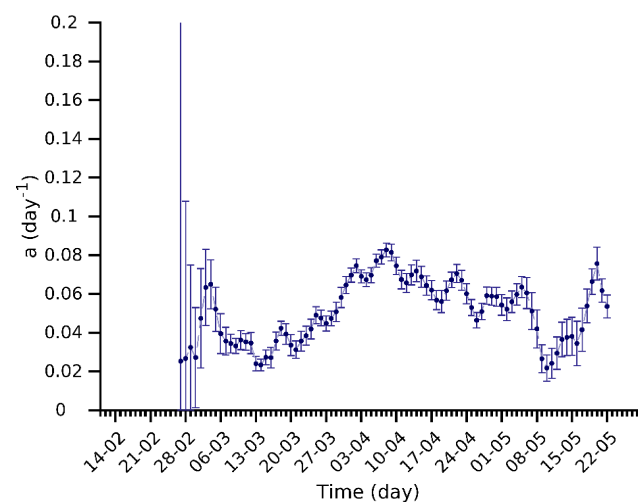
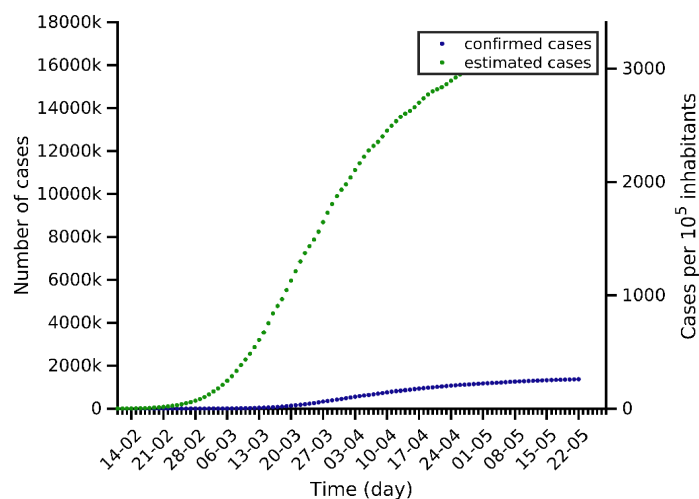
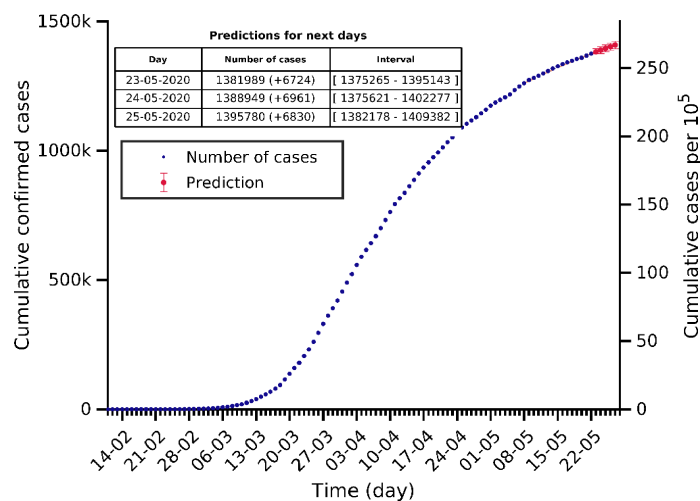


Deaths /
cumulated
reported cases

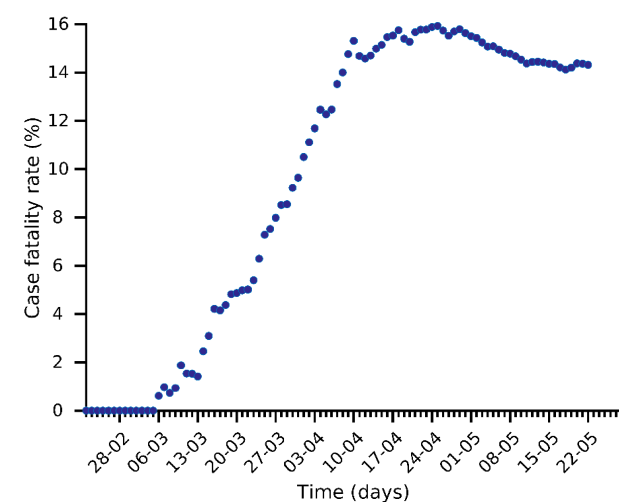
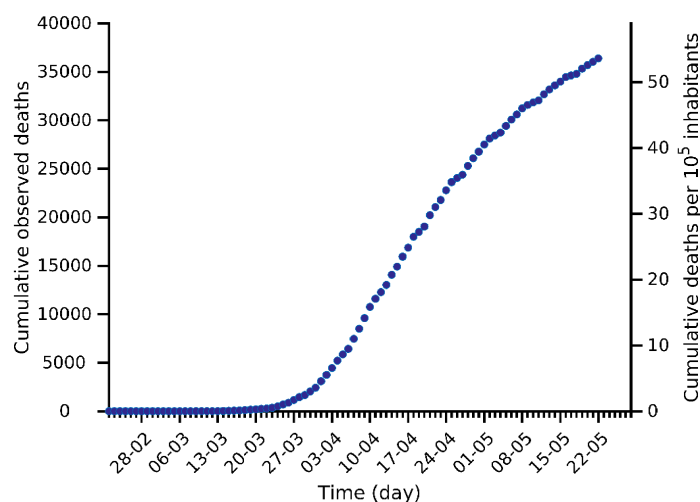
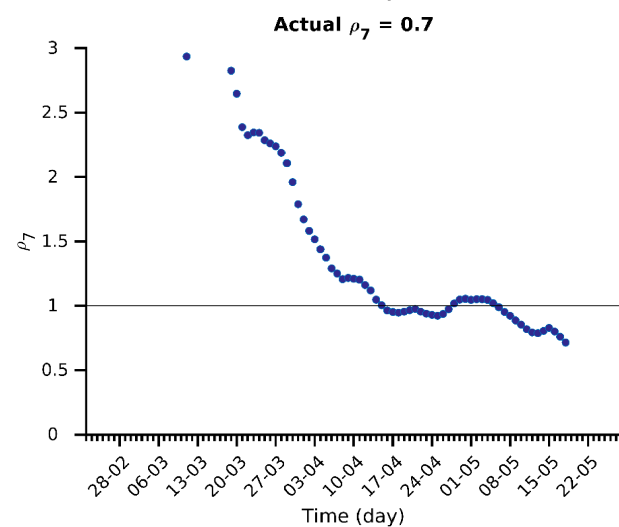
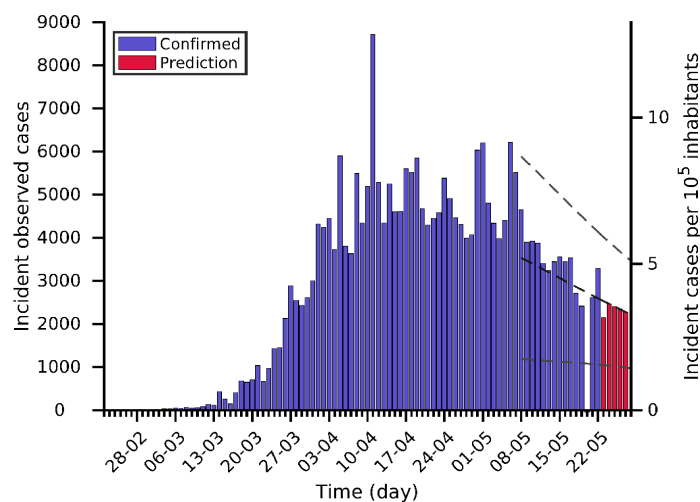
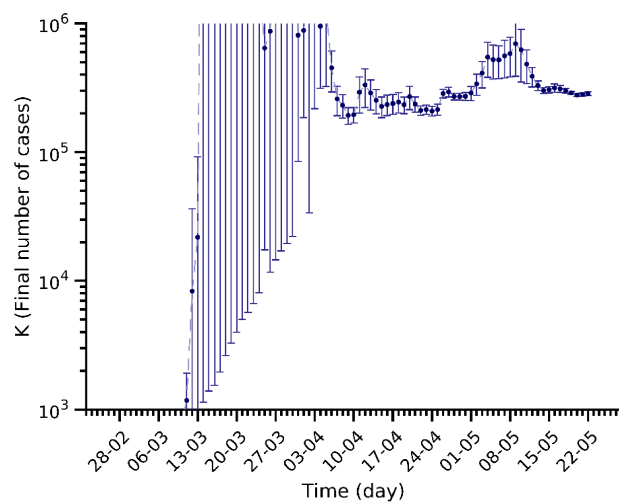
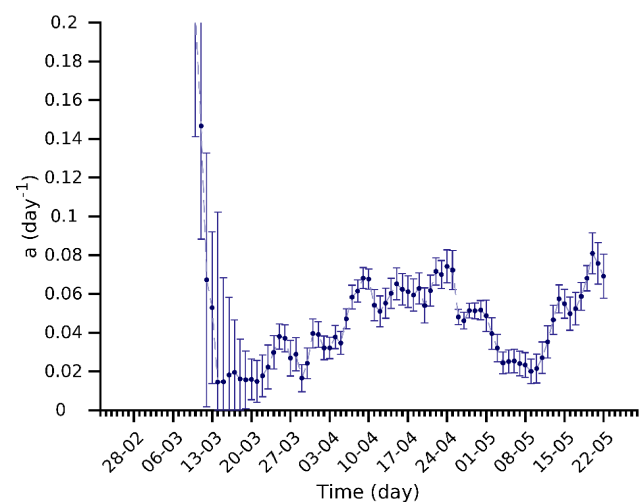
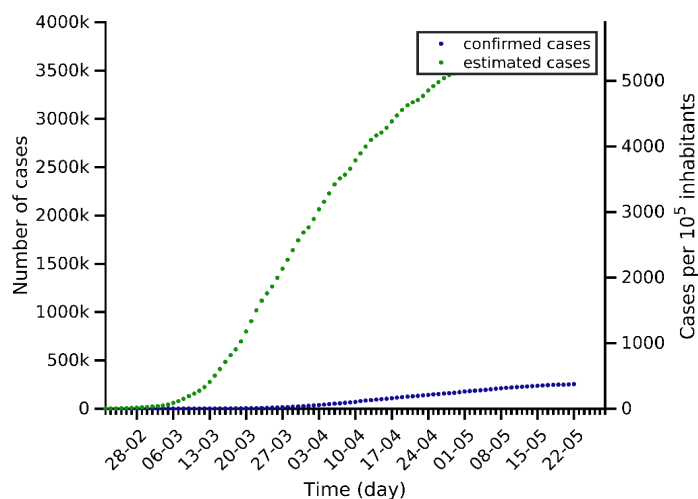
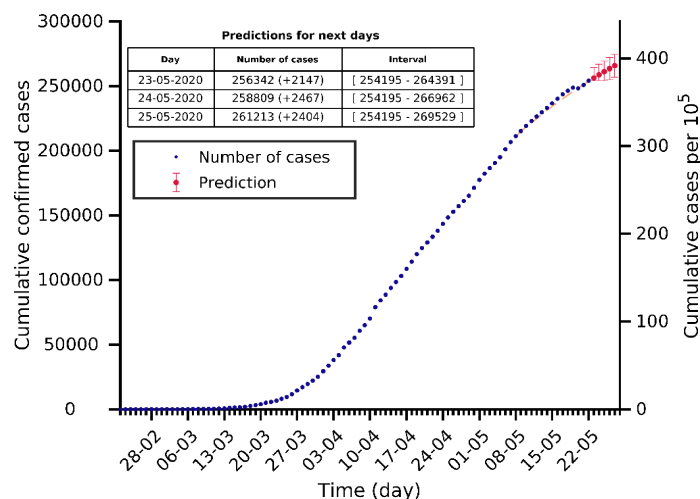


(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

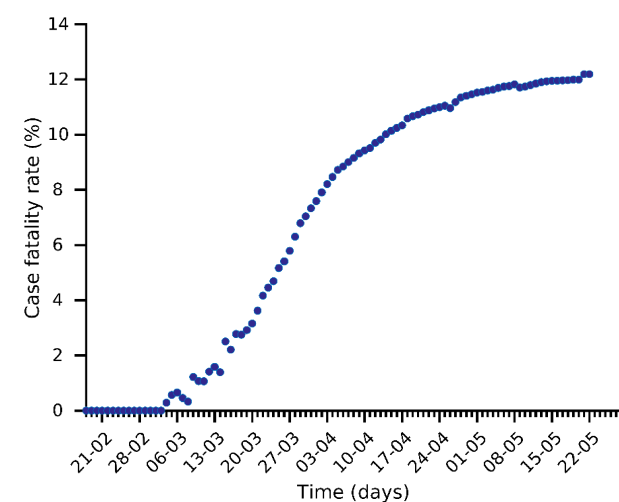
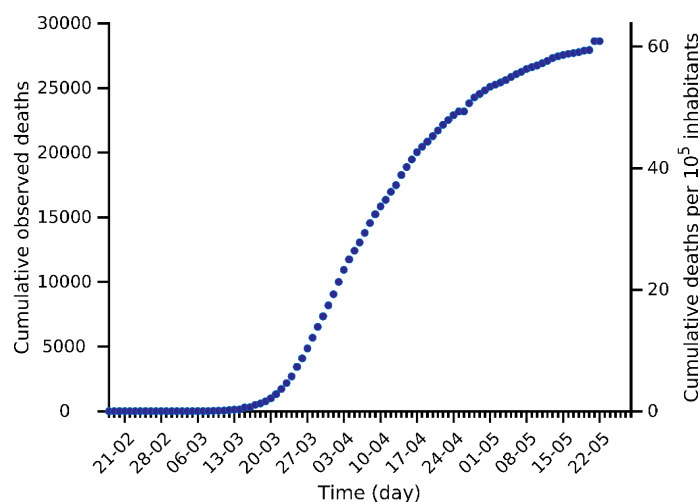
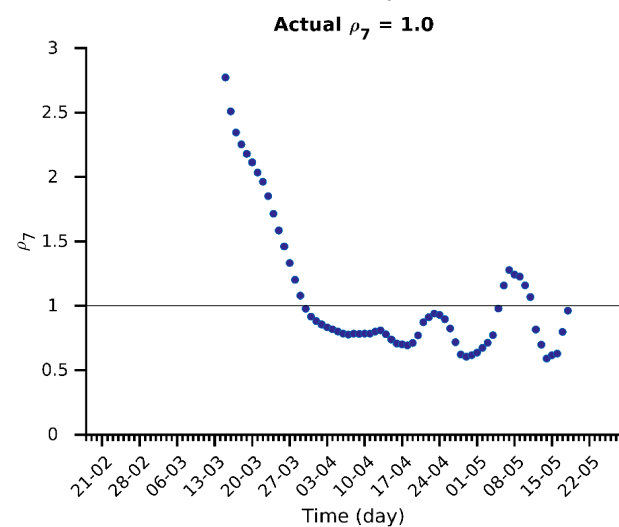
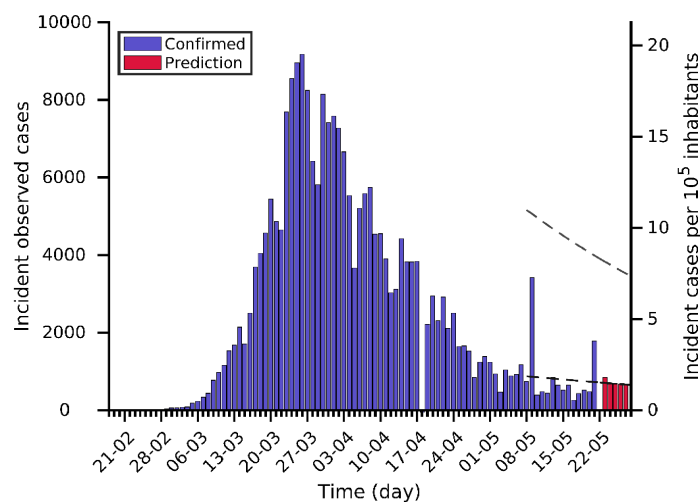
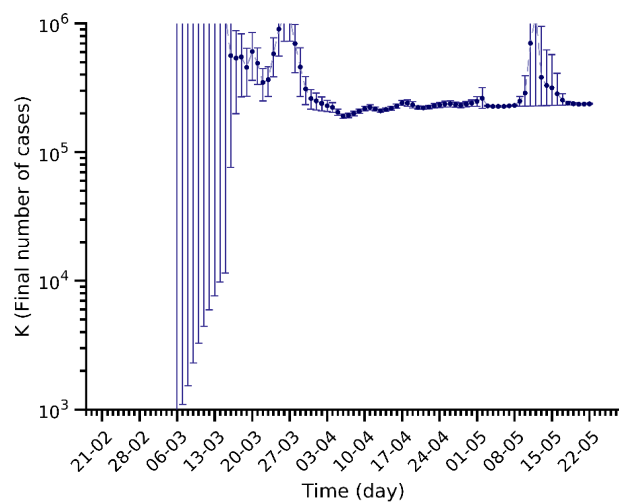
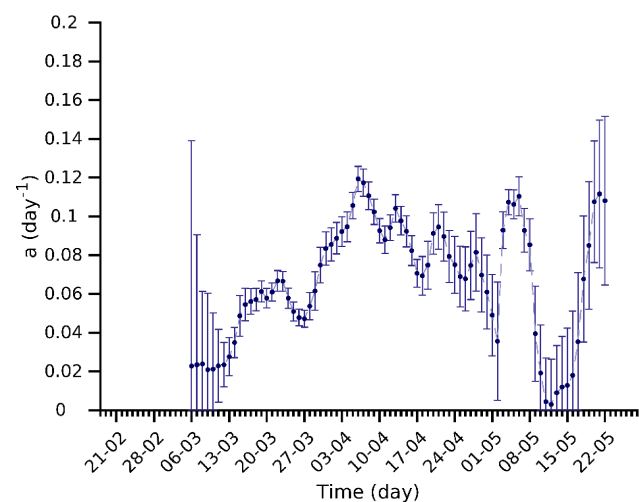
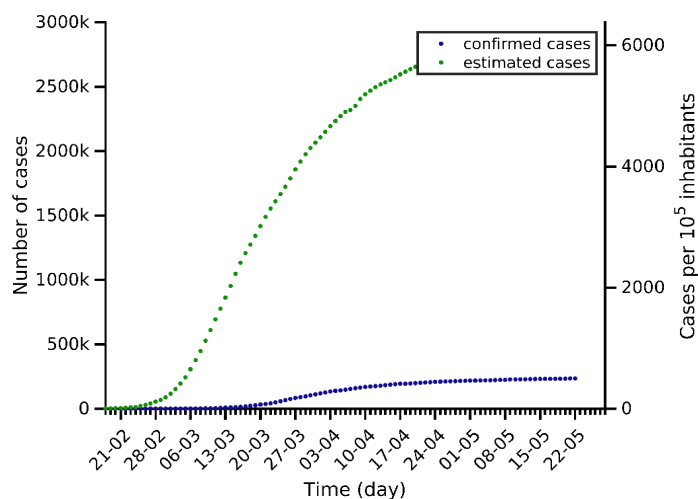
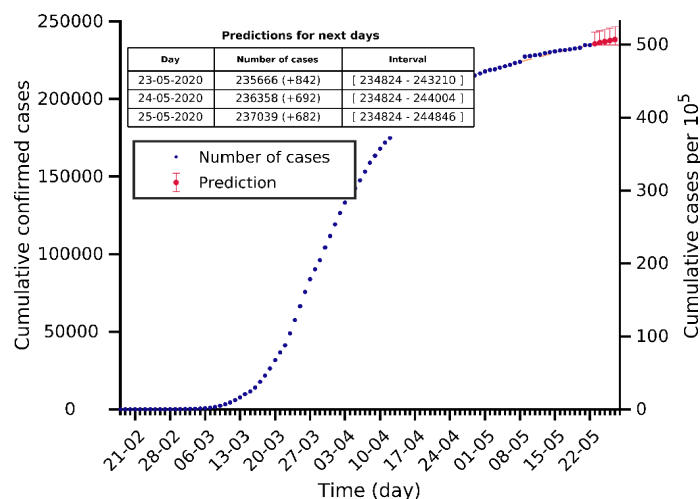
Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>



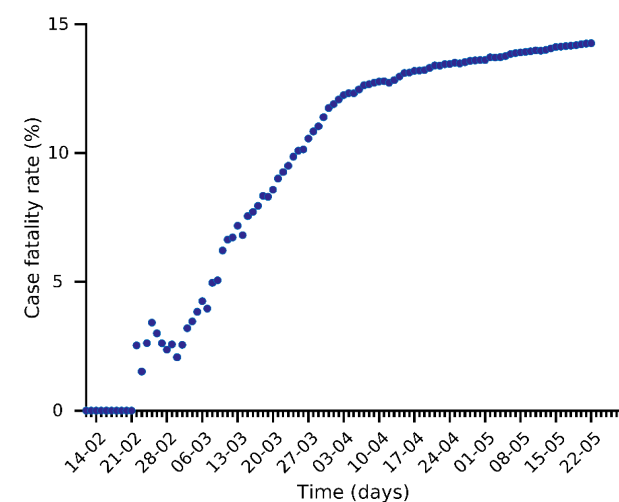
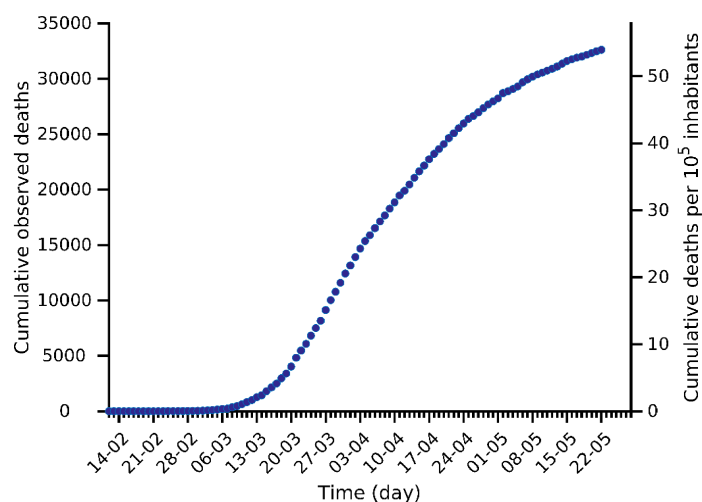
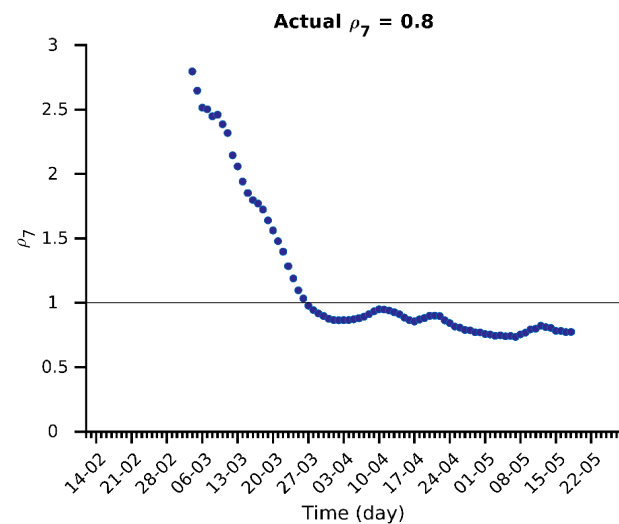
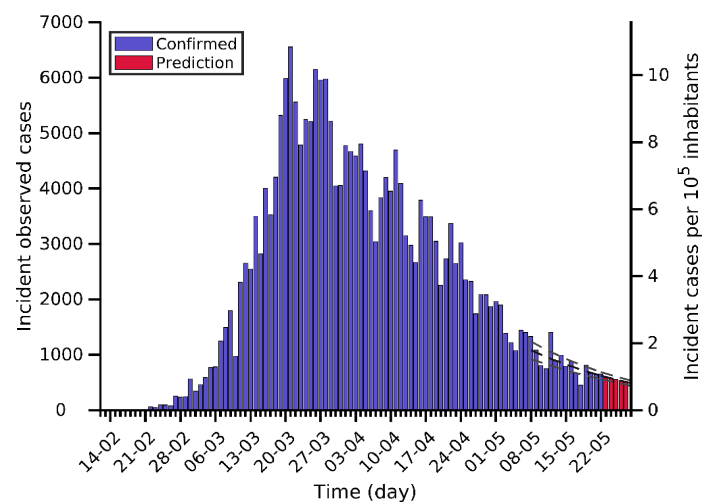
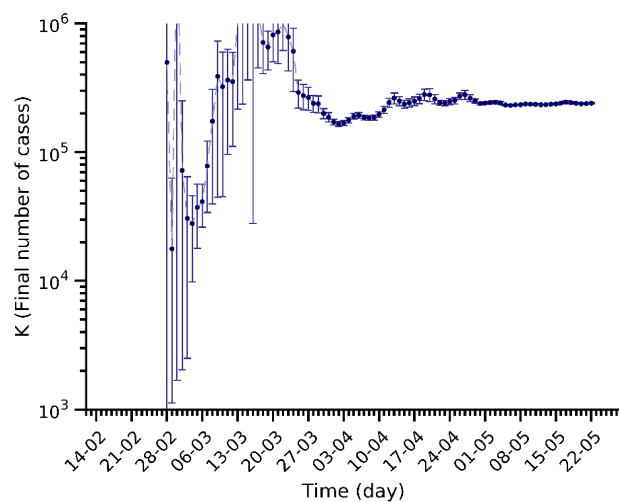
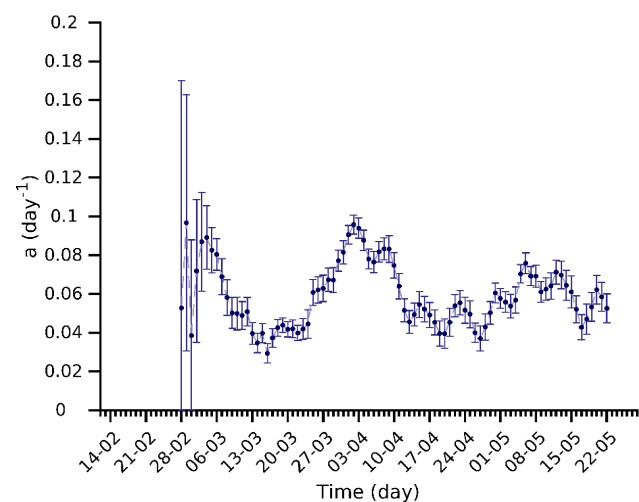
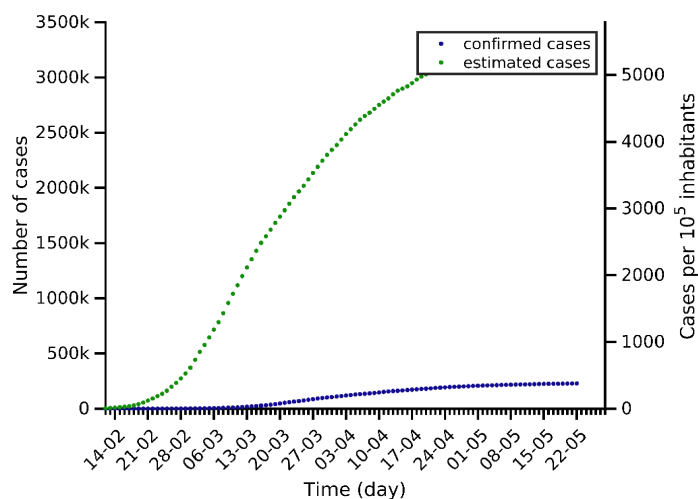
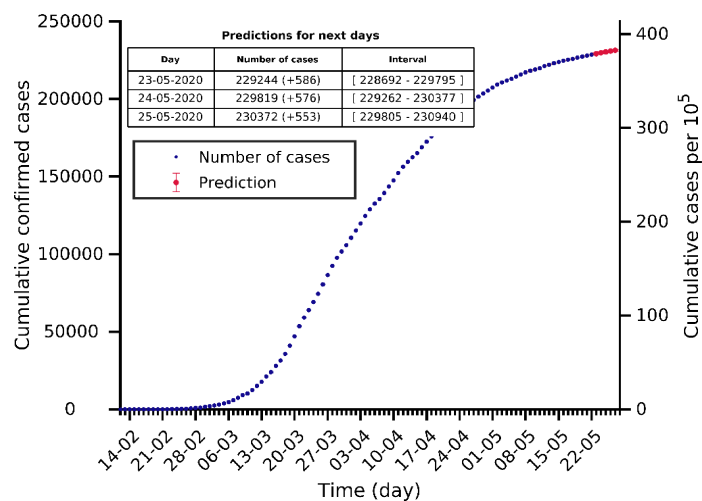
UK 22-05-2020. Population: 67.9M. Current cumulated incidence: 374/10⁵



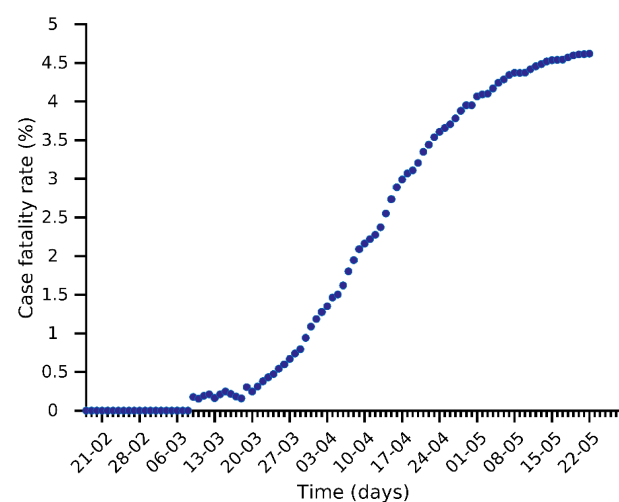
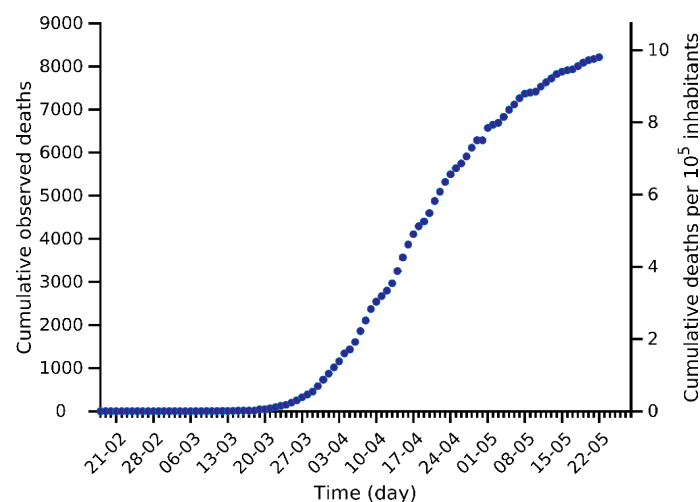
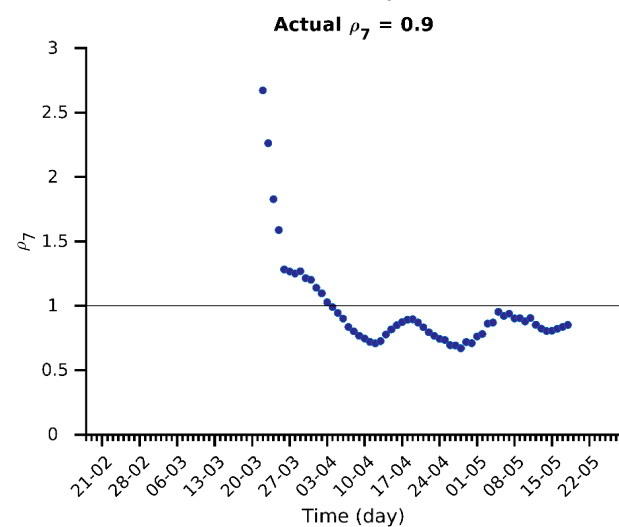
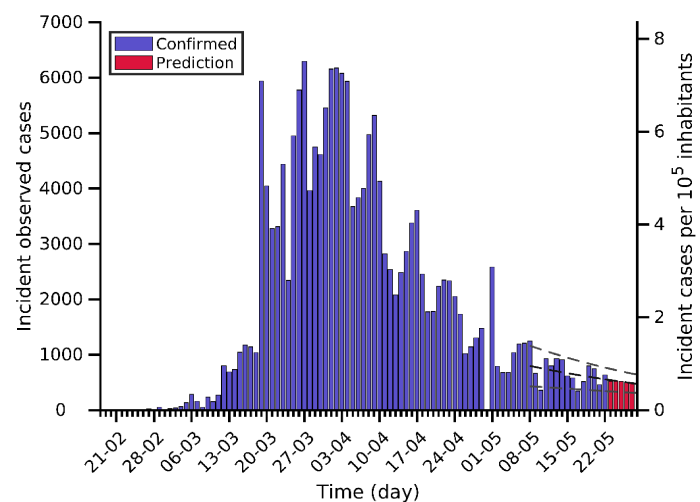
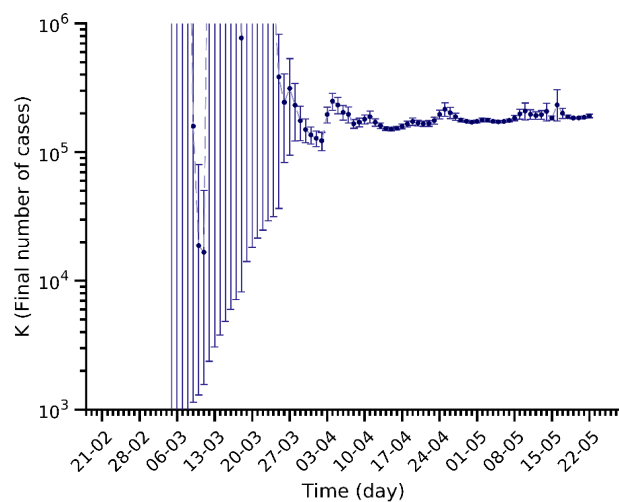
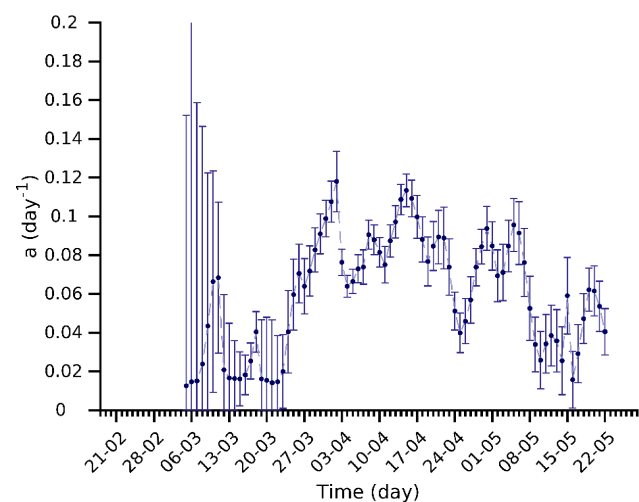
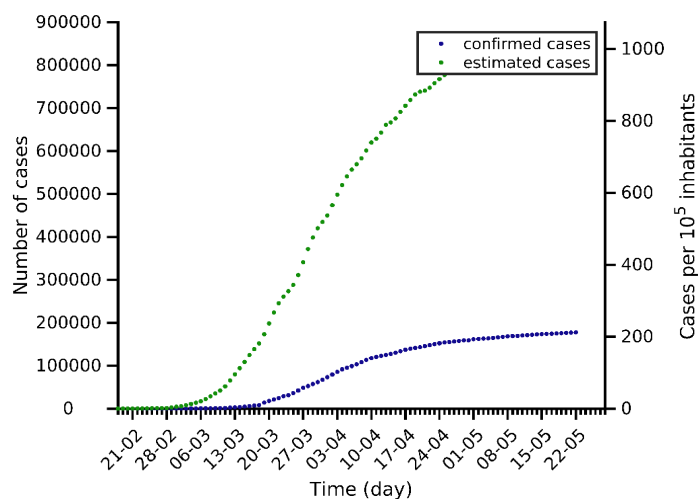
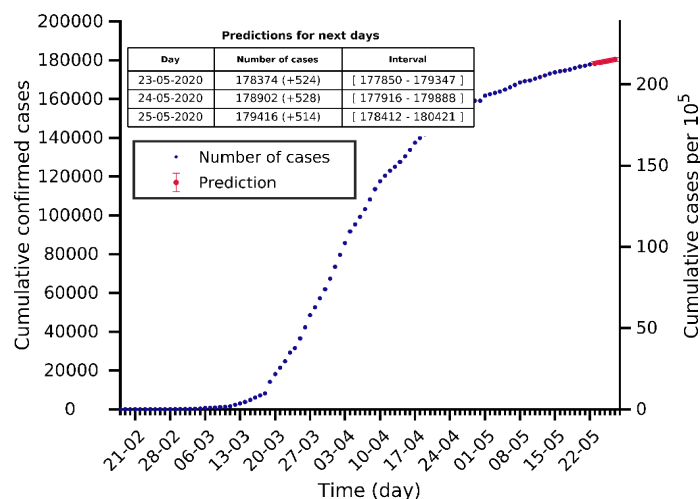
Spain 22-05-2020. Population: 47.0M. Current cumulated incidence: 499/10⁵



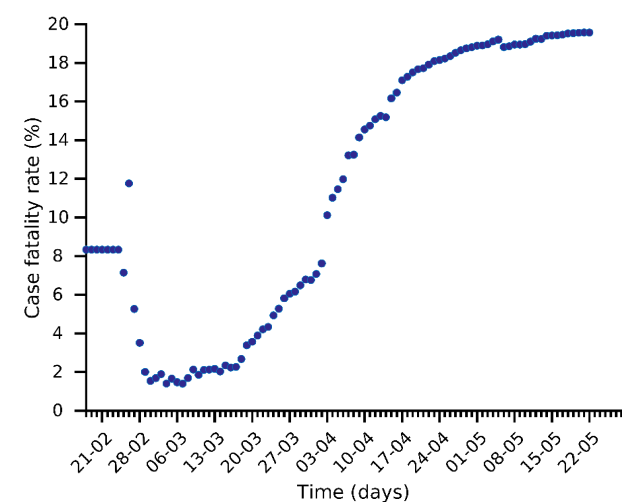
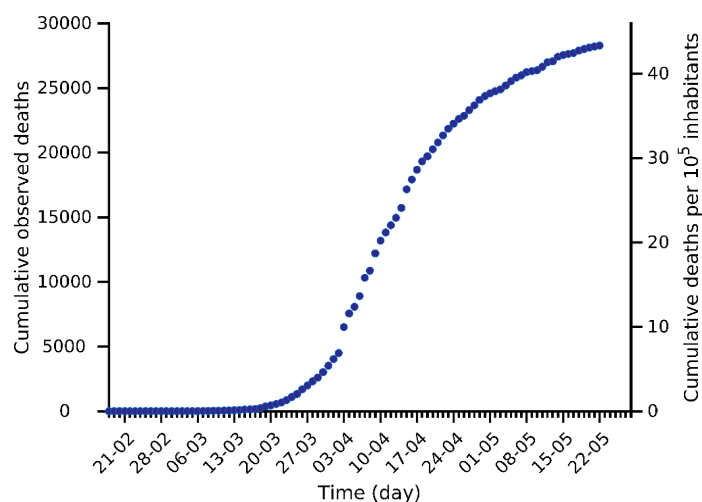
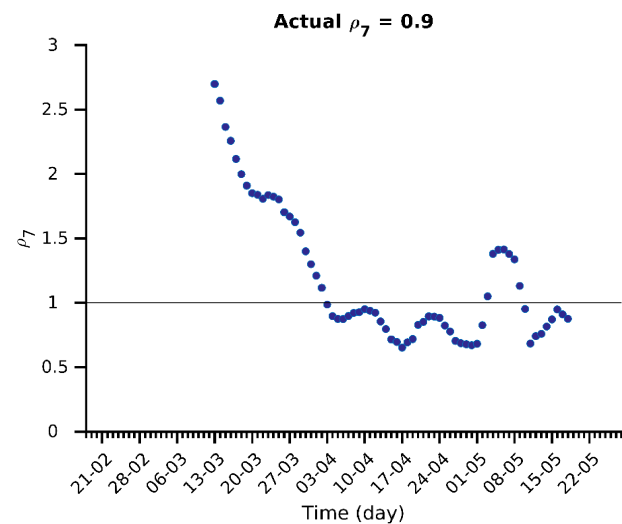
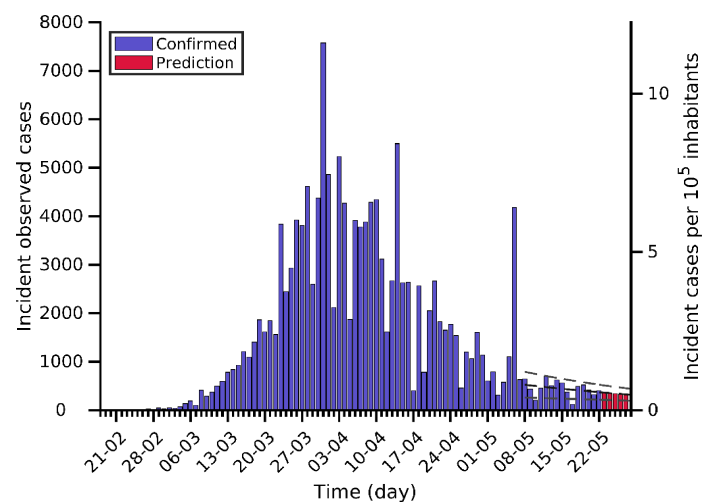
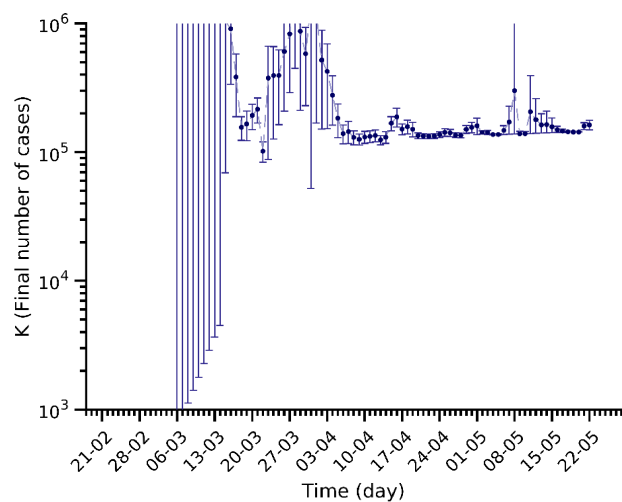
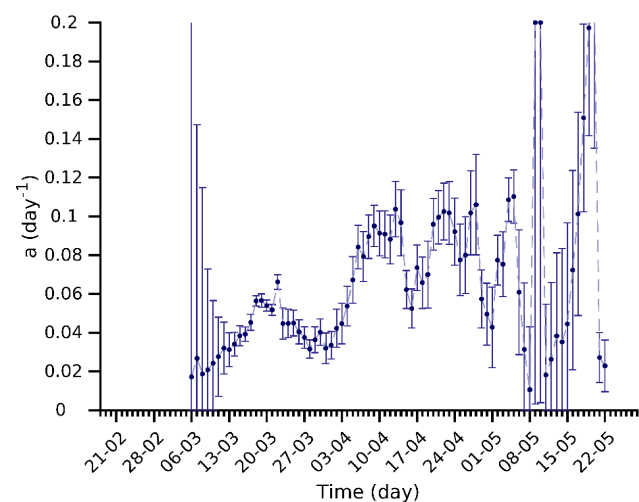
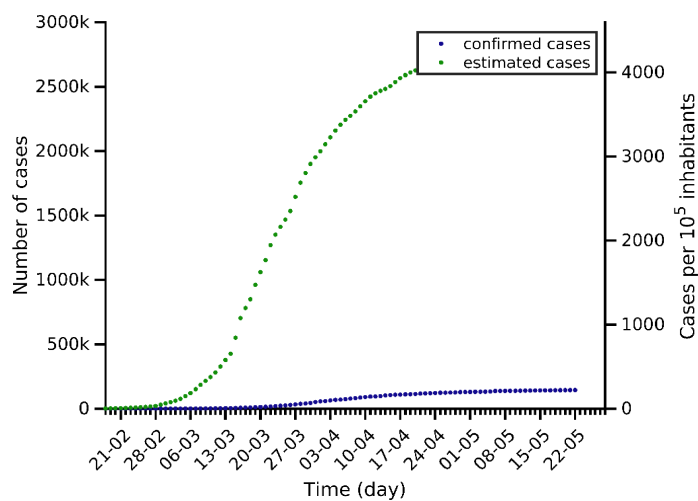
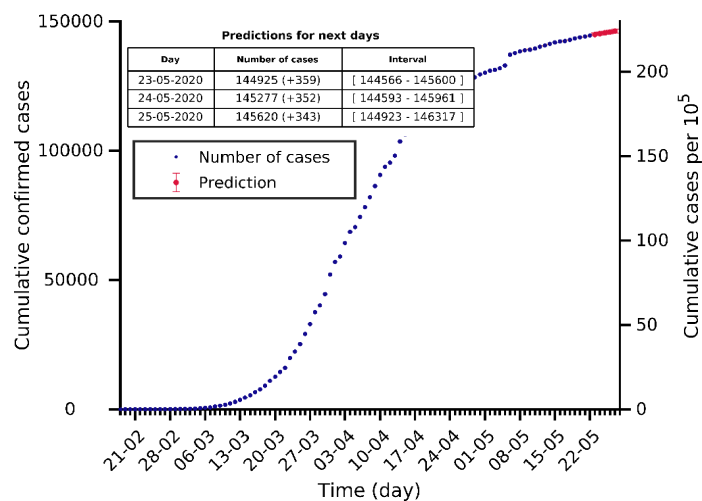
Italy 22-05-2020. Population: 60.5M. Current cumulated incidence: 378/10⁵



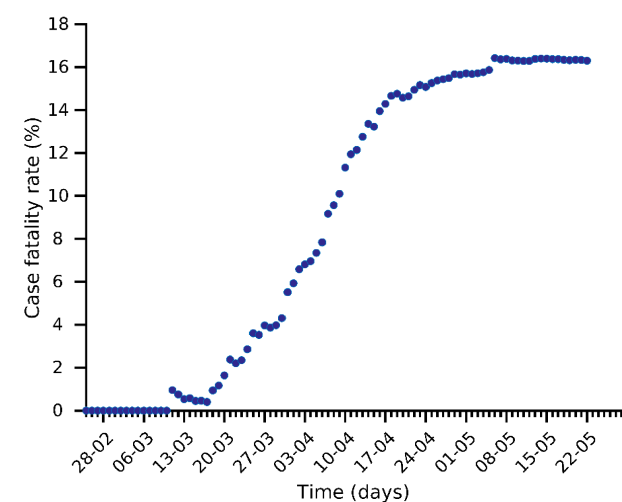
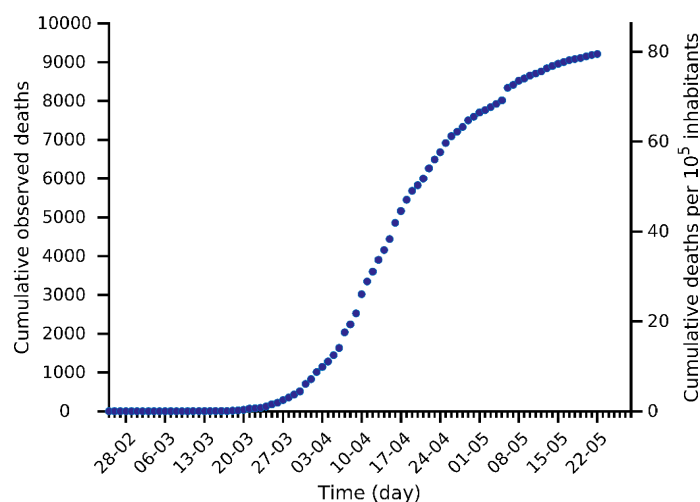
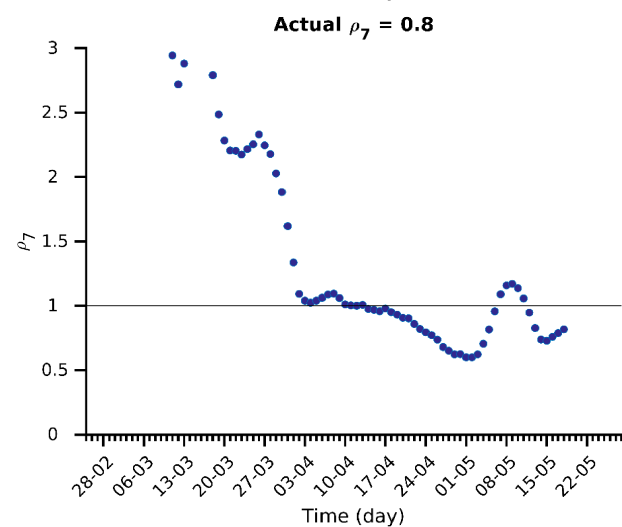
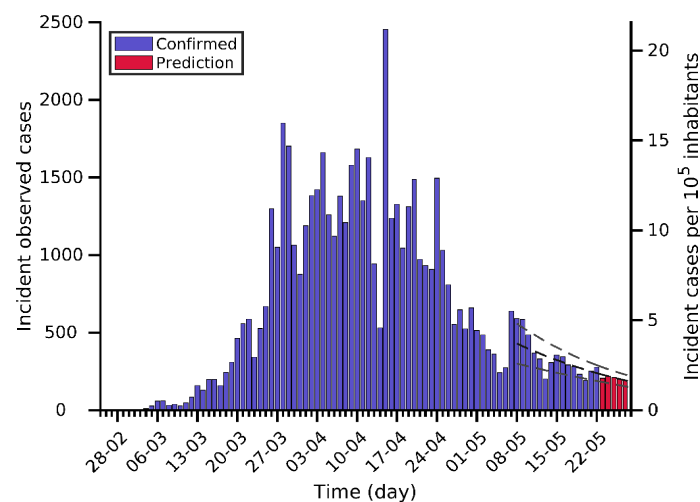
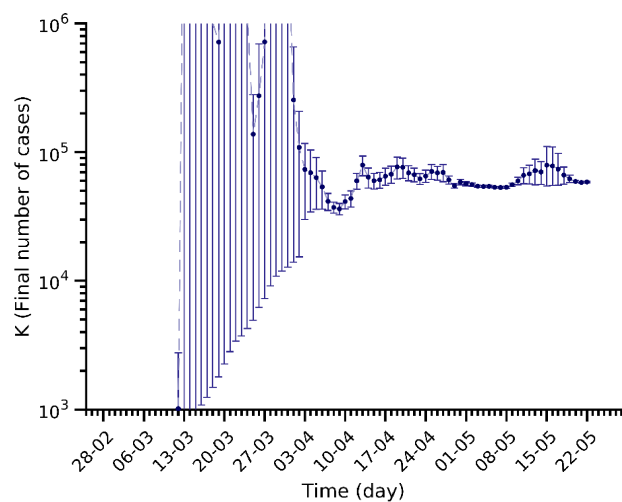
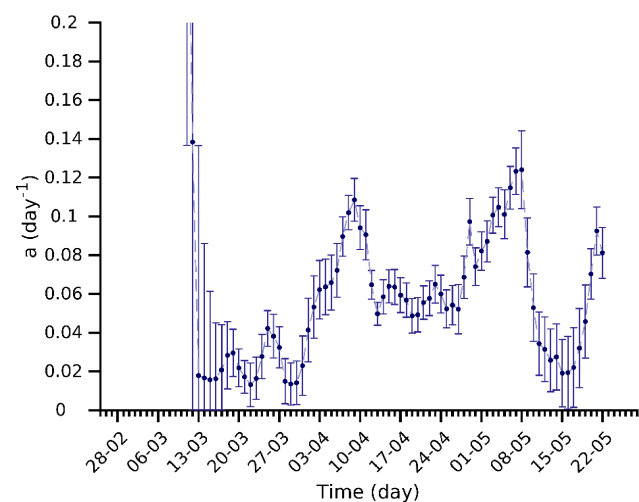
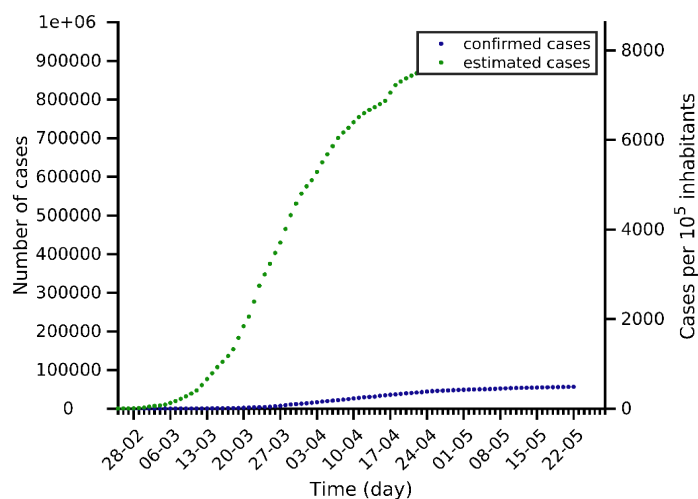
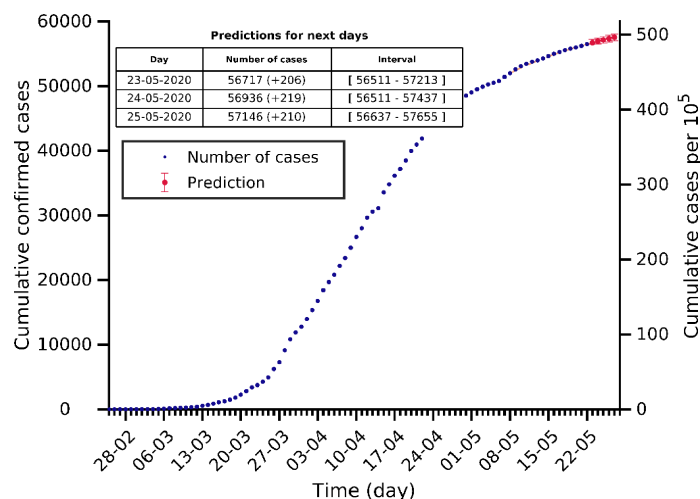
Germany 22-05-2020. Population: 83.8M. Current cumulated incidence: 212/10⁵



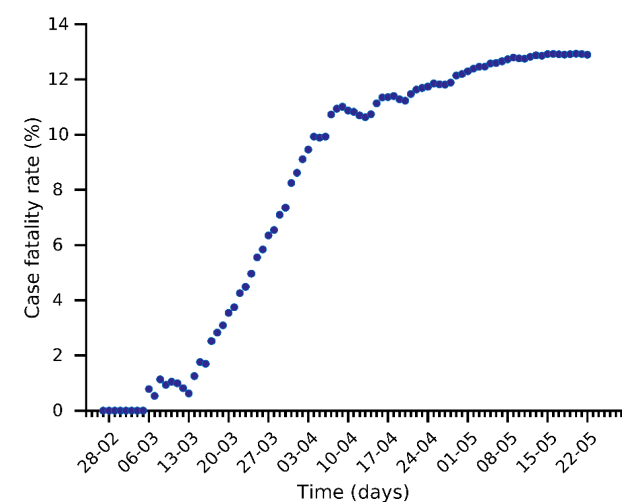
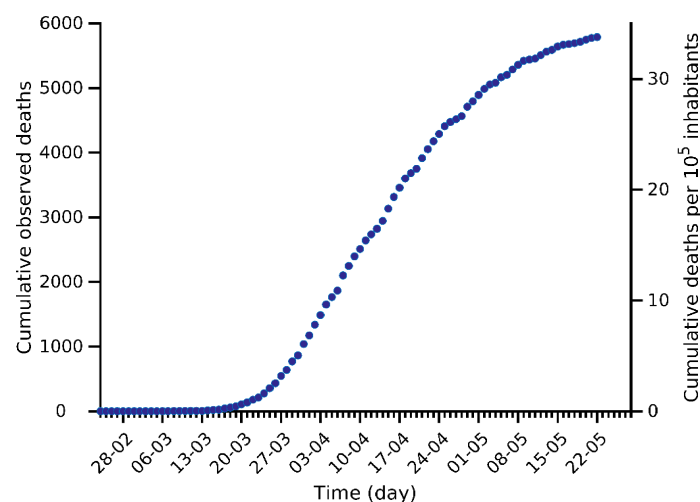
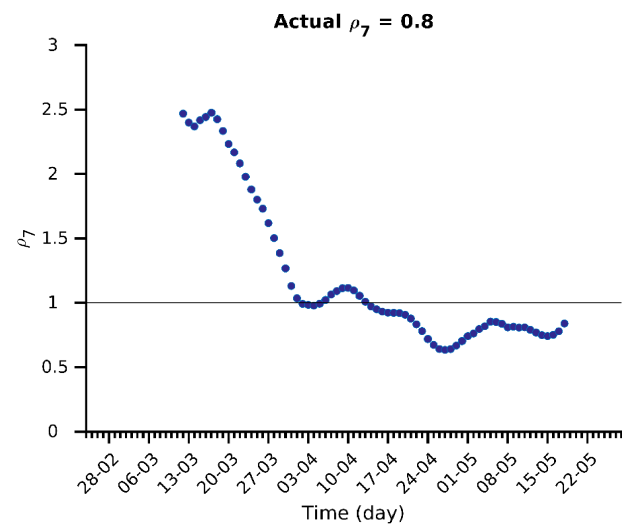
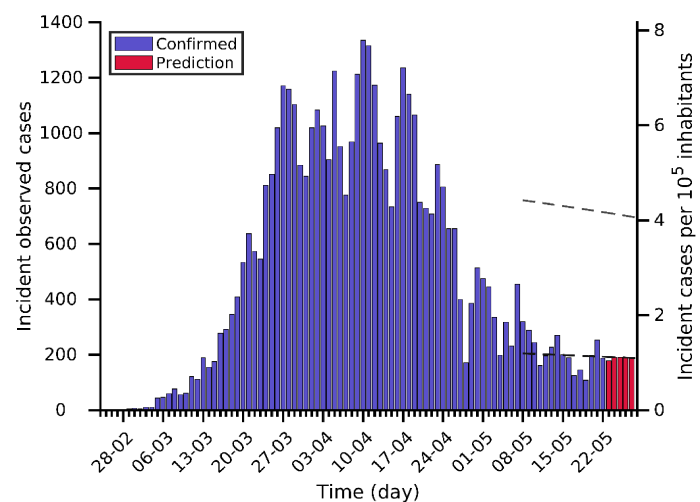
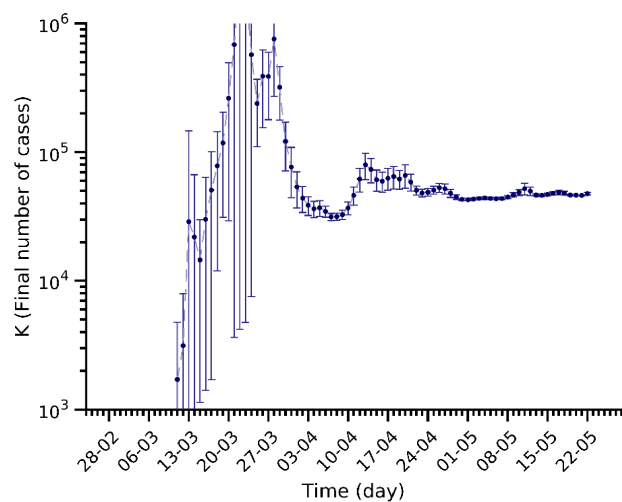
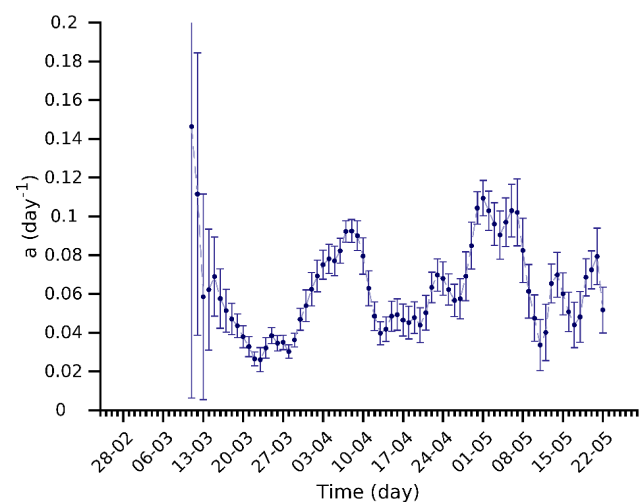
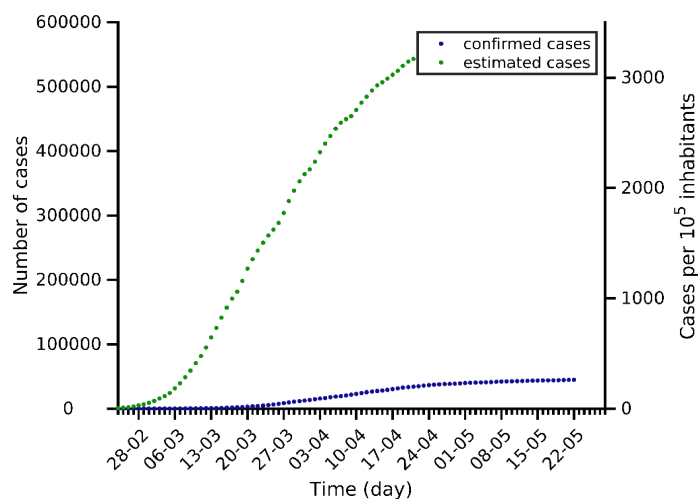
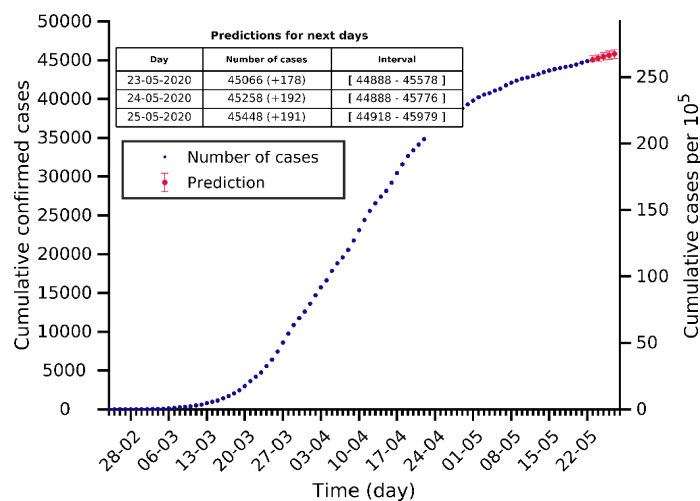
France 22-05-2020. Population: 65.3M. Current cumulated incidence: 221/10⁵



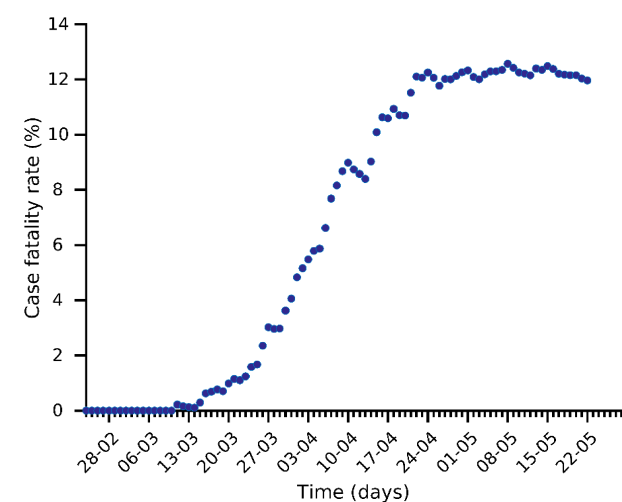
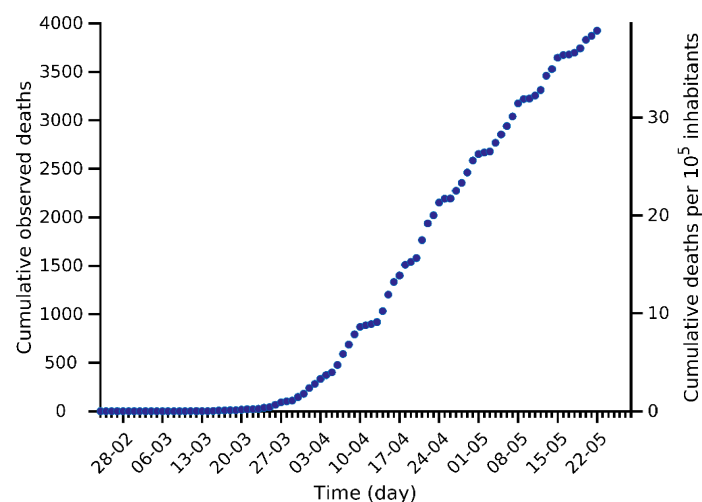
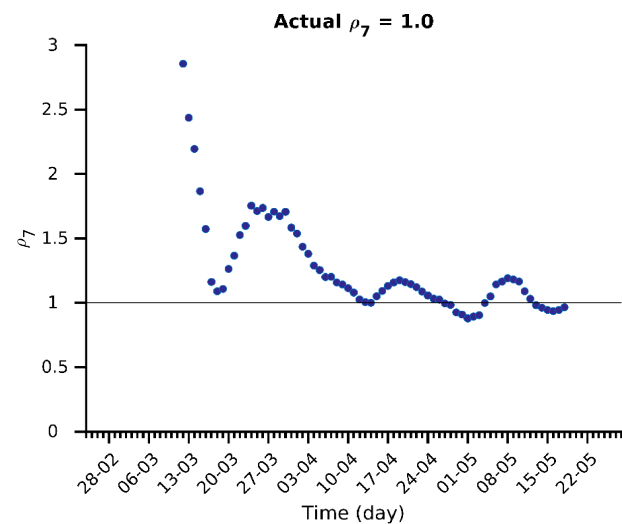
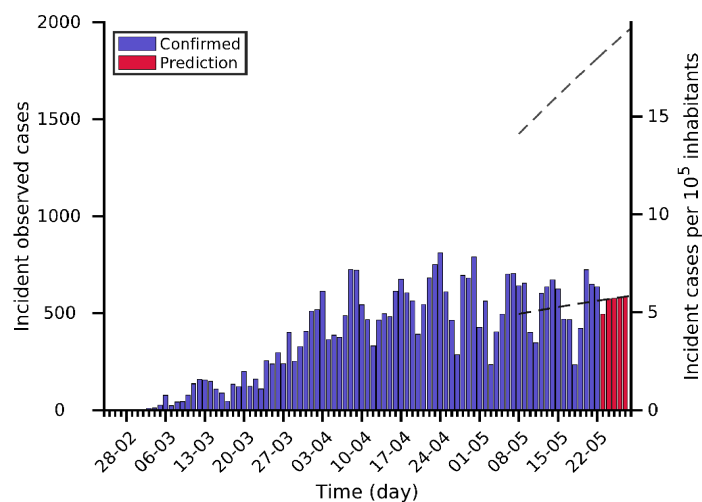
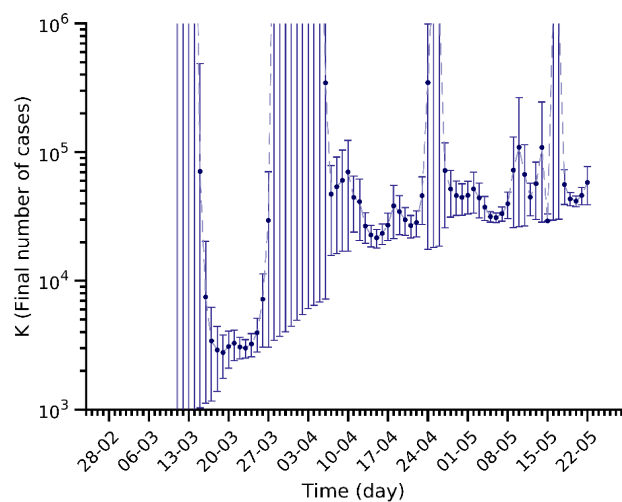
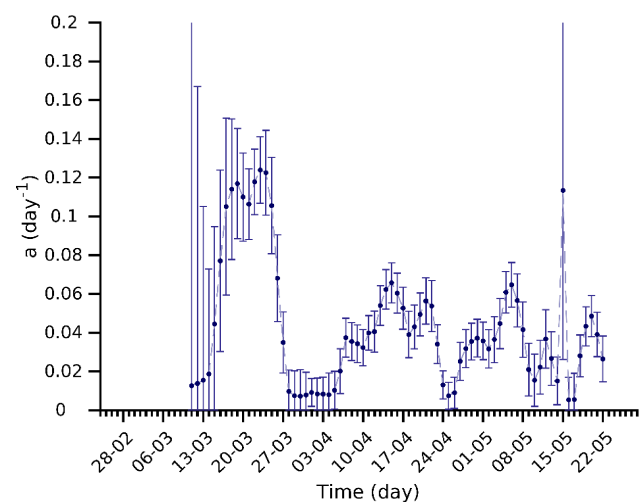
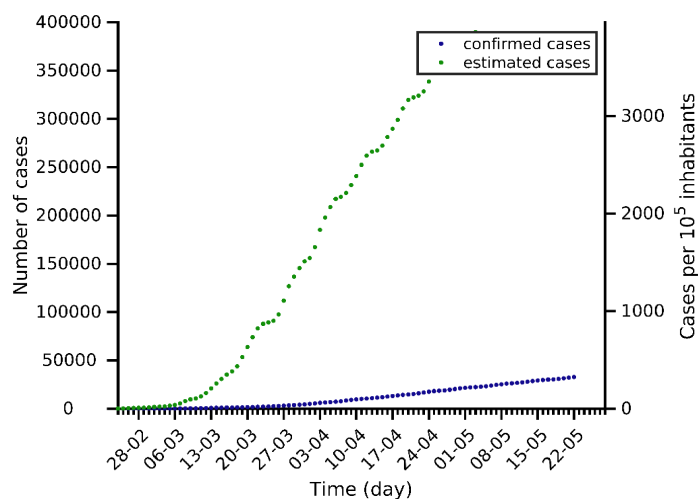
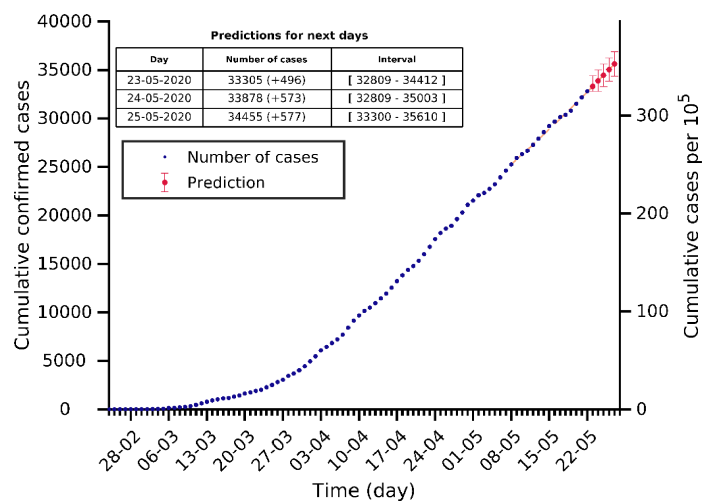
Belgium 22-05-2020. Population: 11.6M. Current cumulated incidence: 488/10⁵



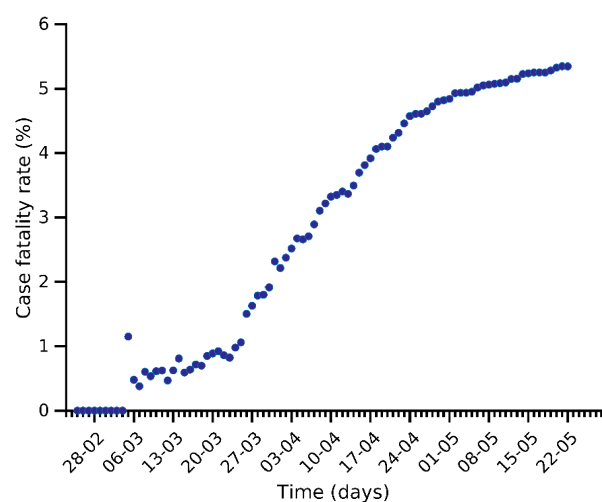
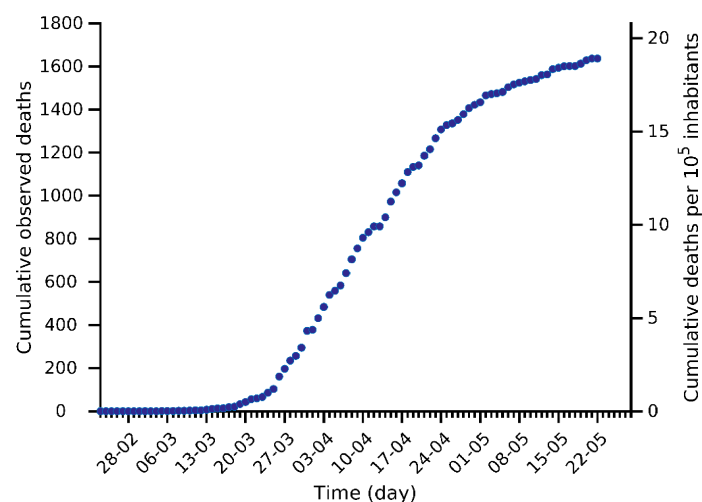
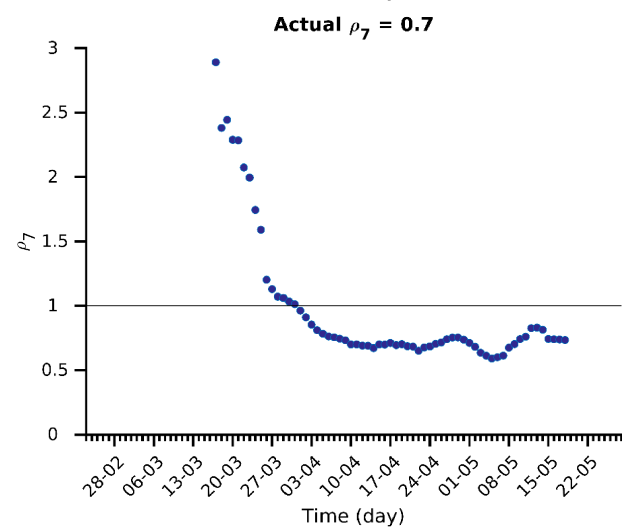
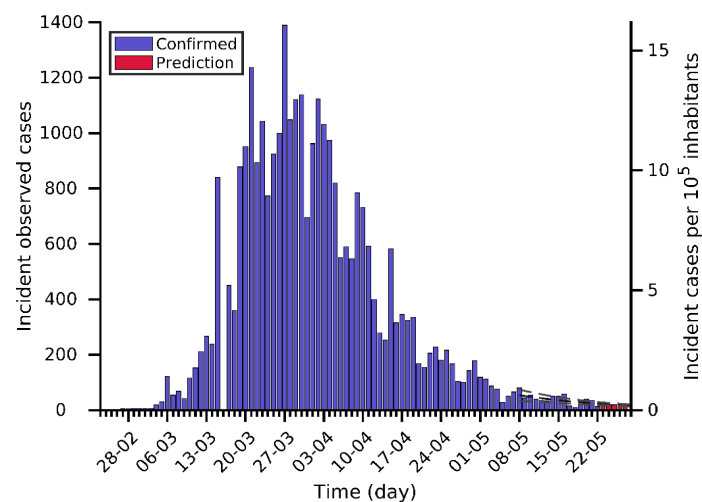
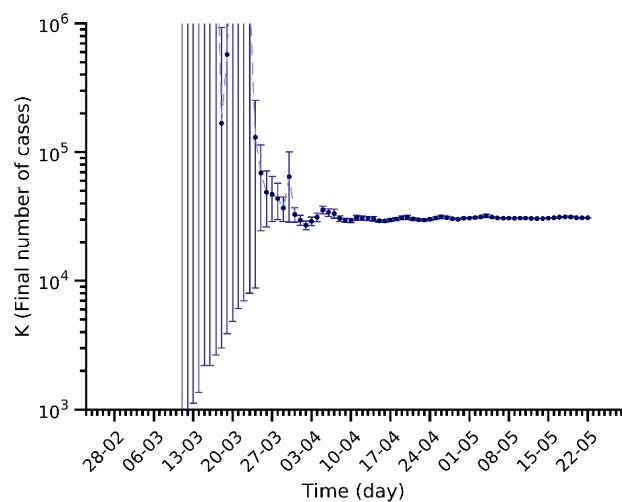
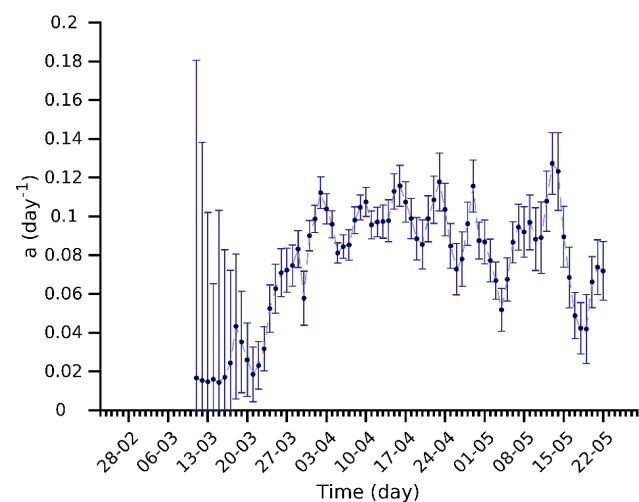
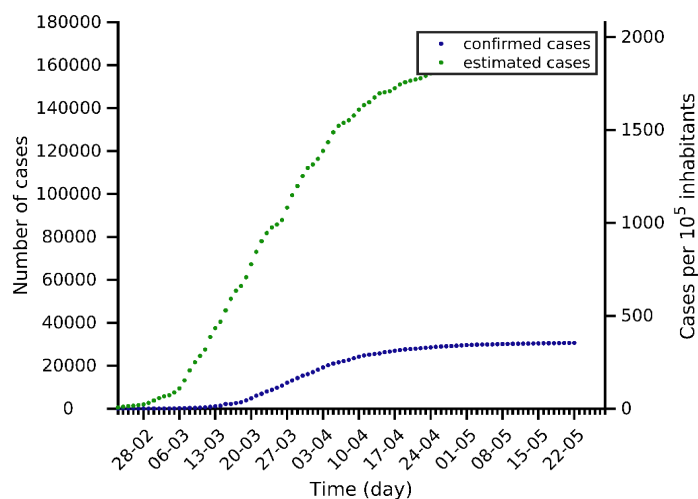
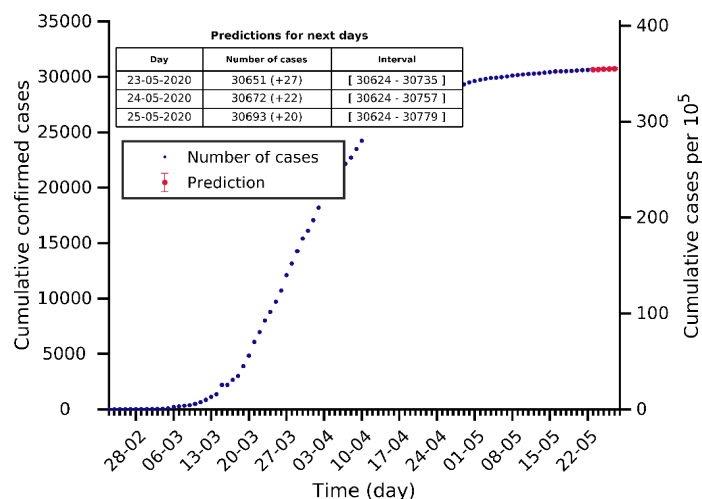
Netherlands 22-05-2020. Population: 17.1M. Current cumulated incidence: 262/10⁵



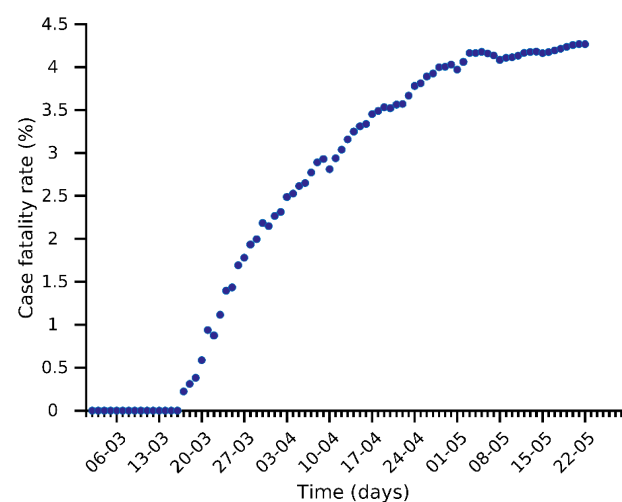
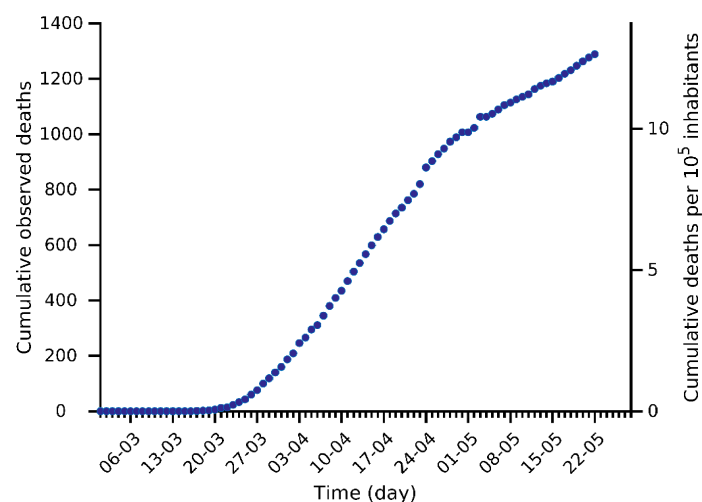
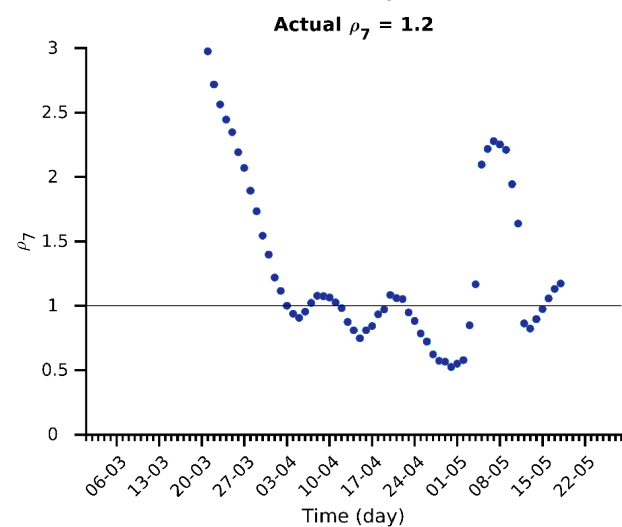
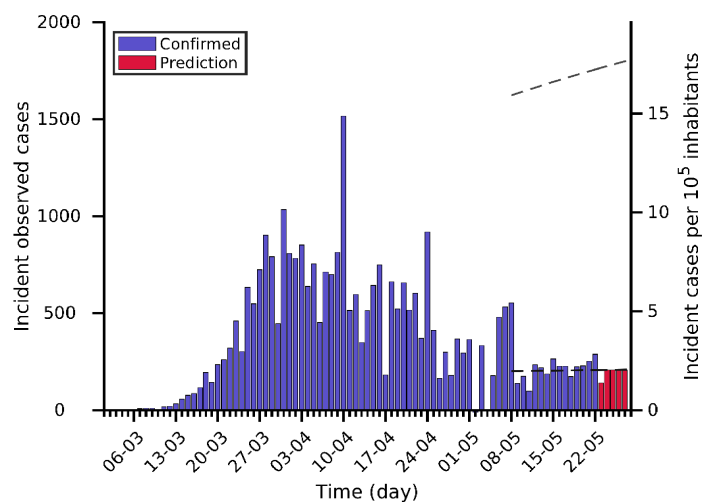
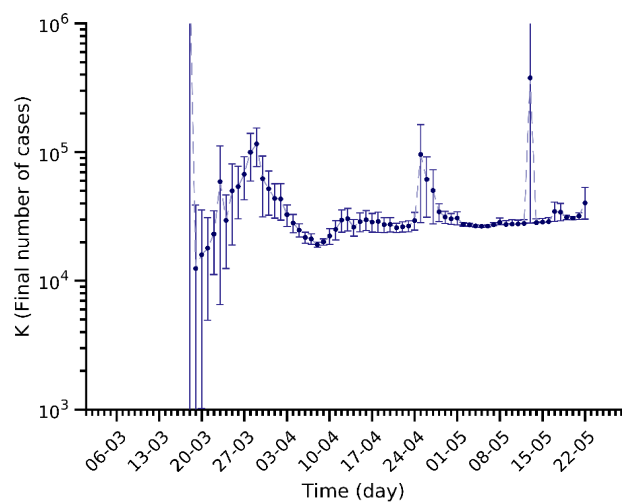
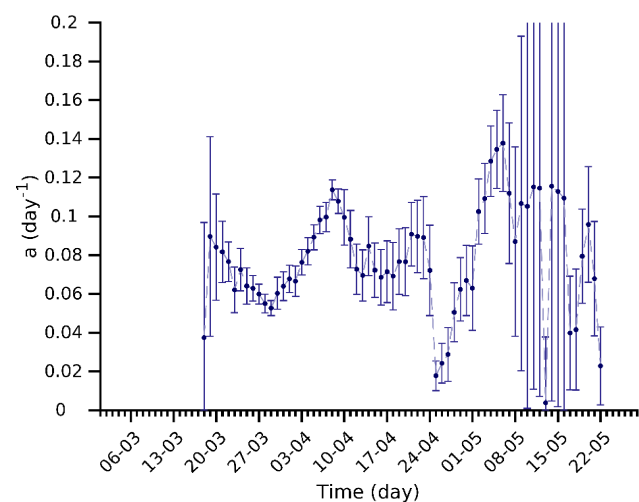
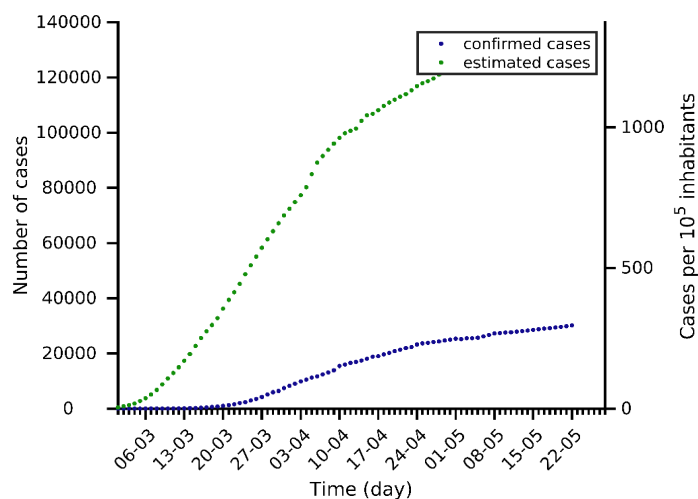
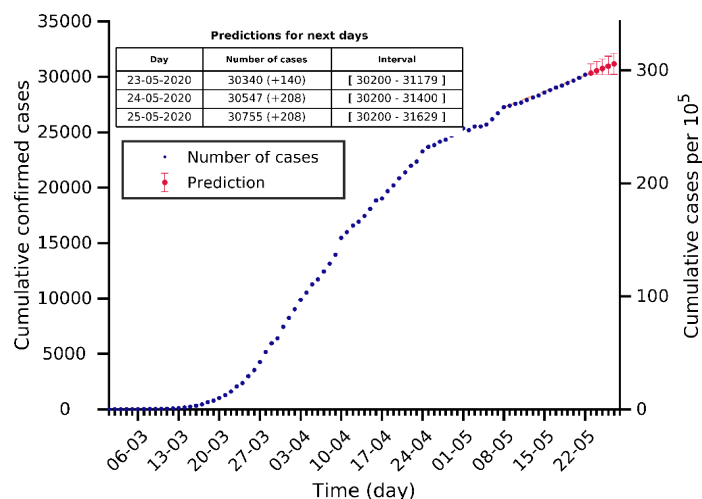
Sweden 22-05-2020. Population: 10.1M. Current cumulated incidence: 325/10⁵



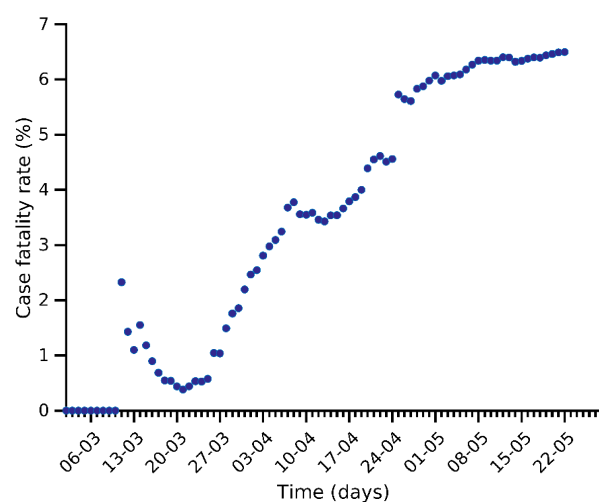
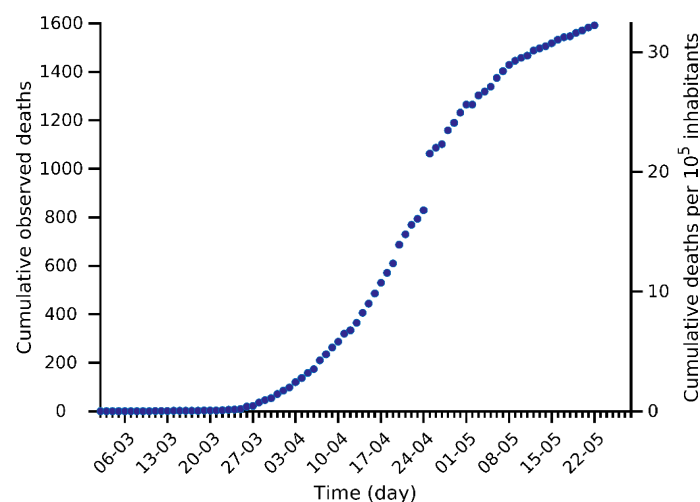
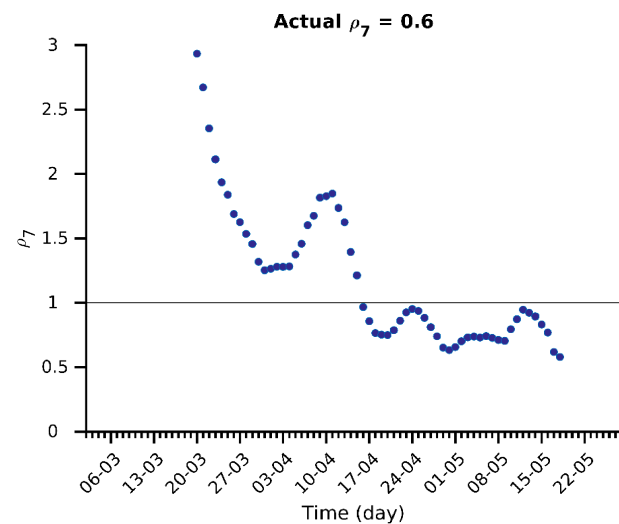
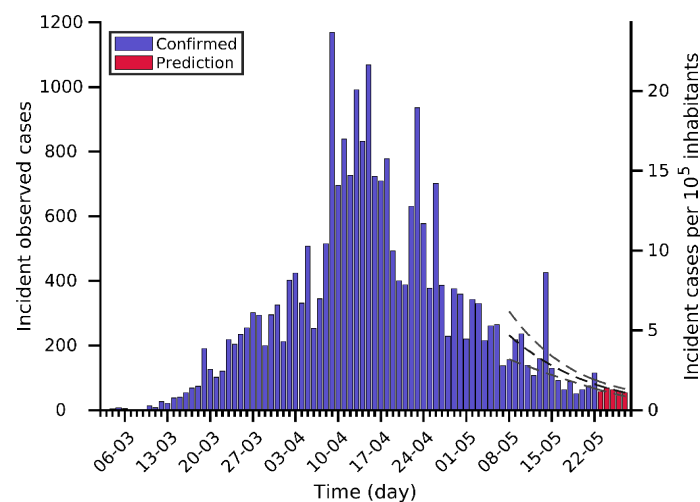
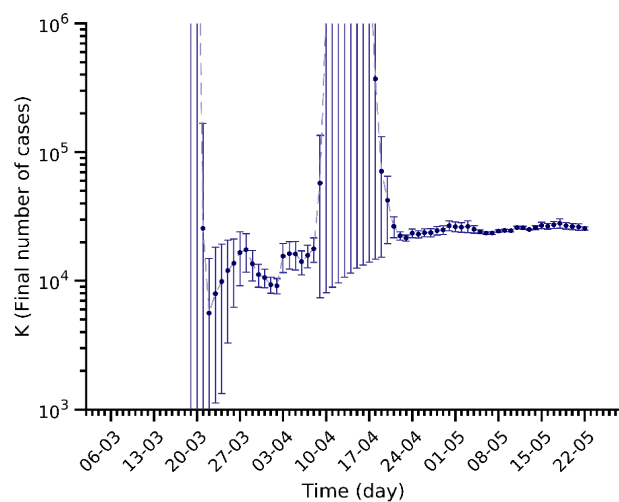
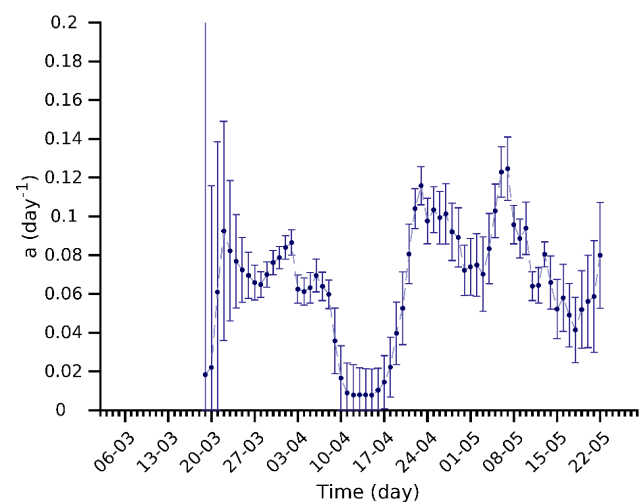
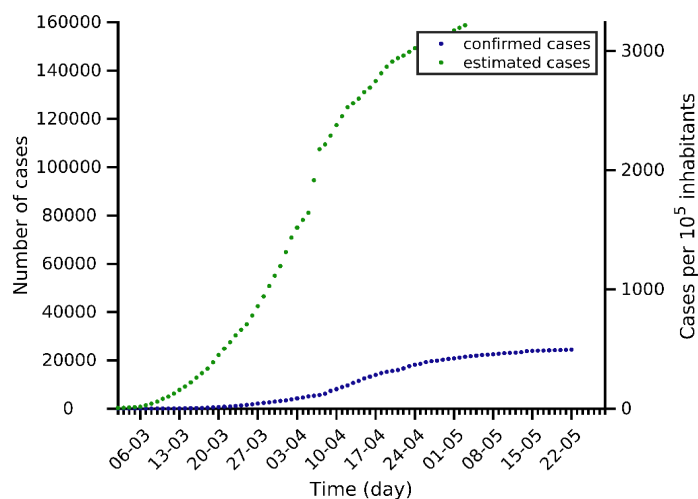
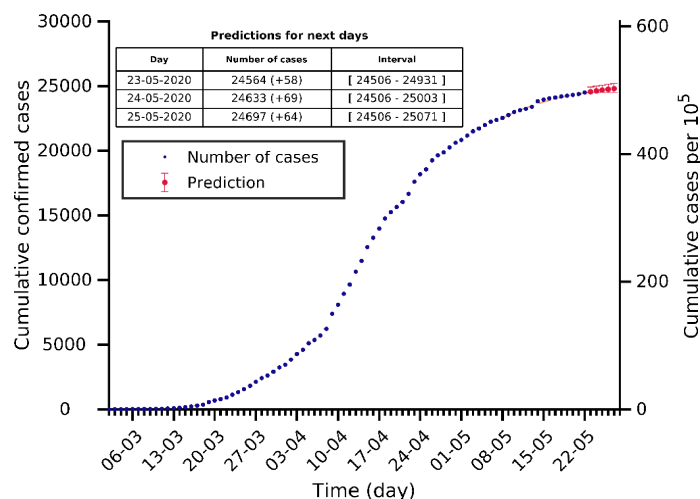
Switzerland 22-05-2020. Population: 8.7M. Current cumulated incidence: 354/10⁵



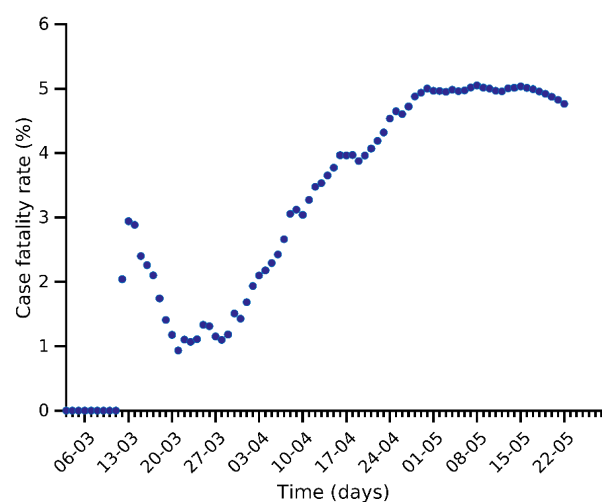
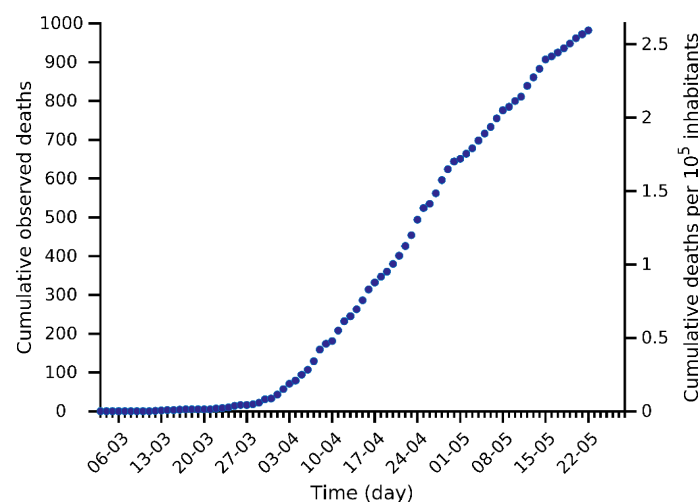
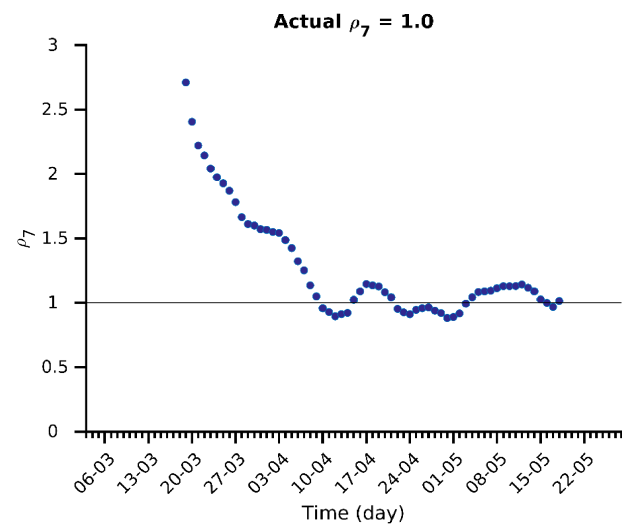
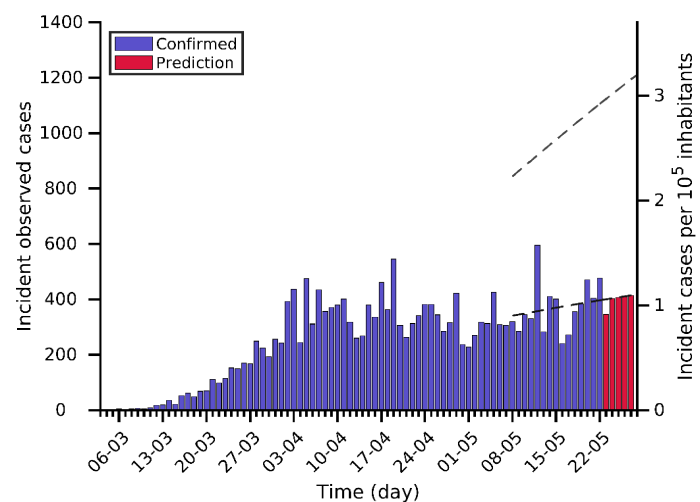
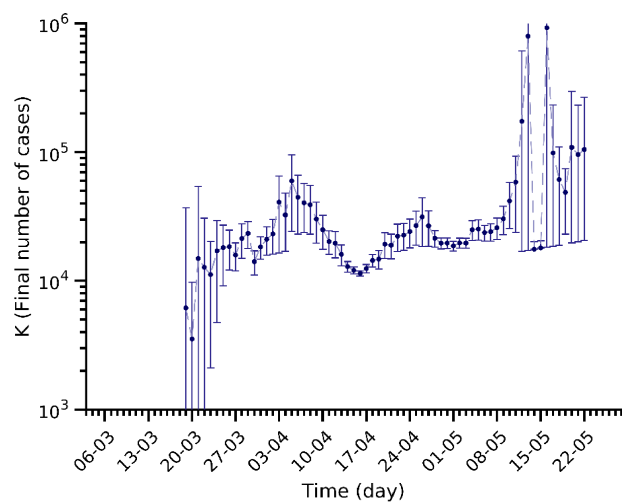
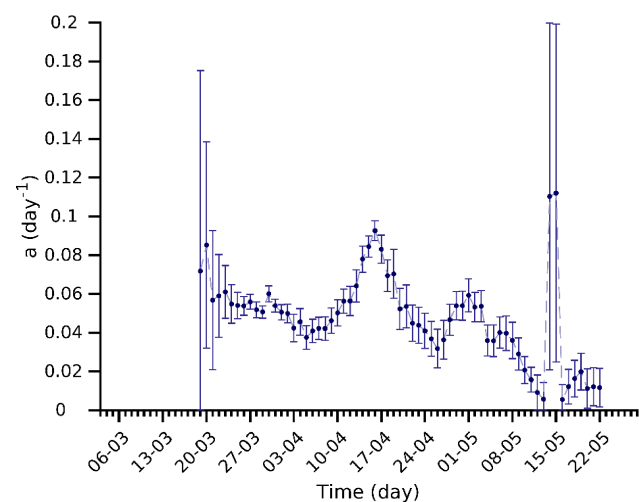
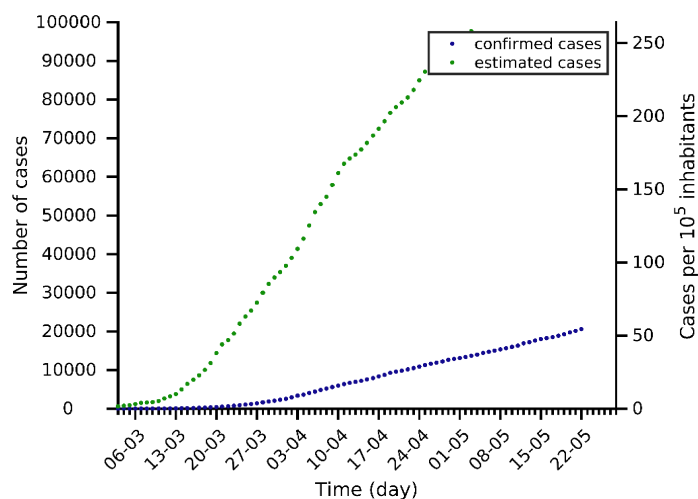
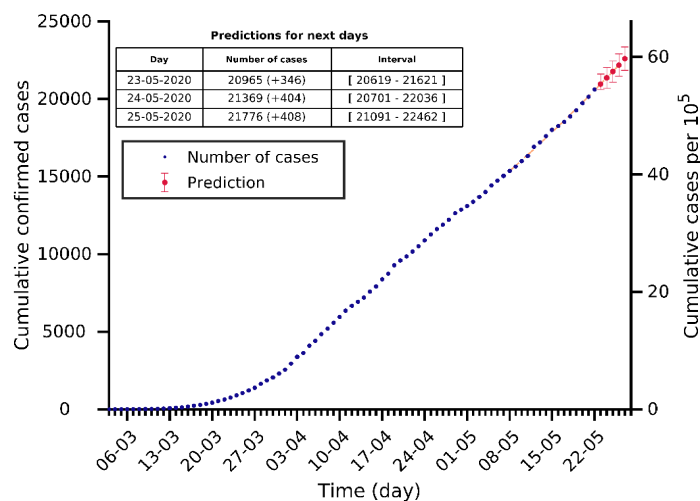
Portugal 22-05-2020. Population: 10.2M. Current cumulated incidence: 296/10⁵



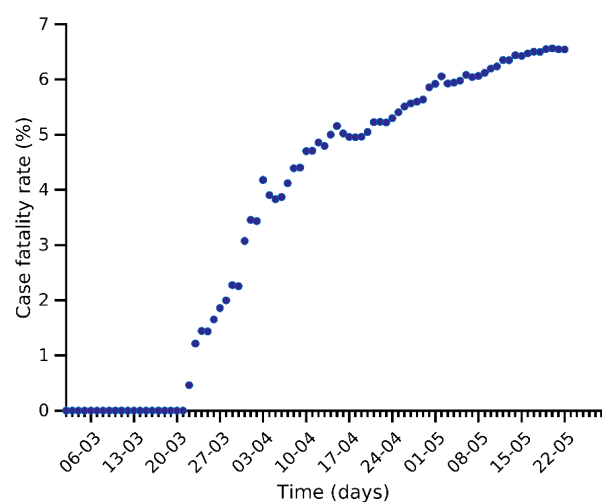
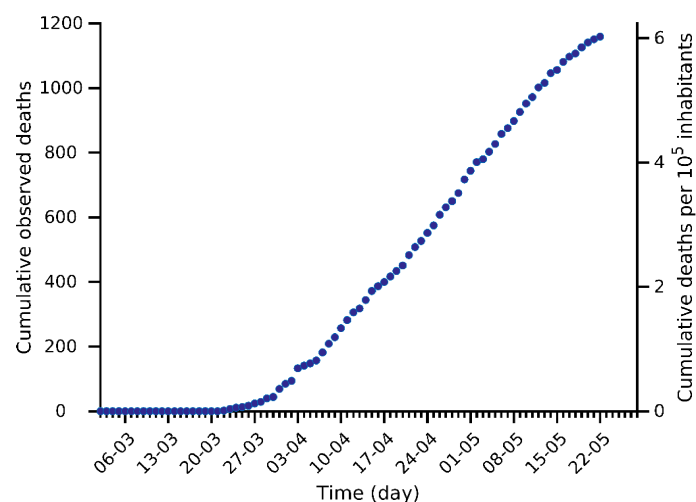
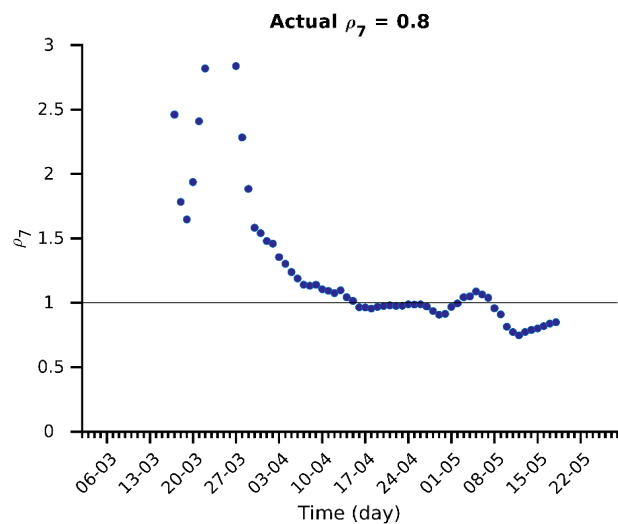
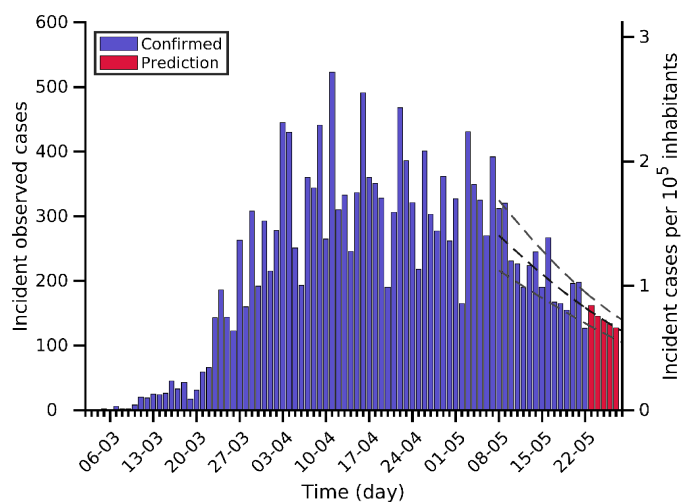
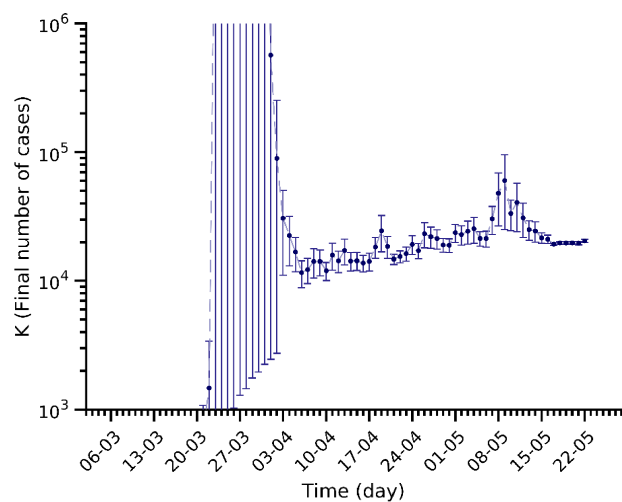
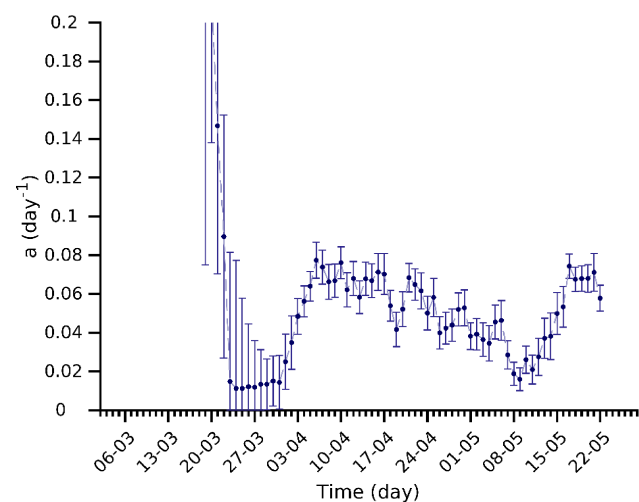
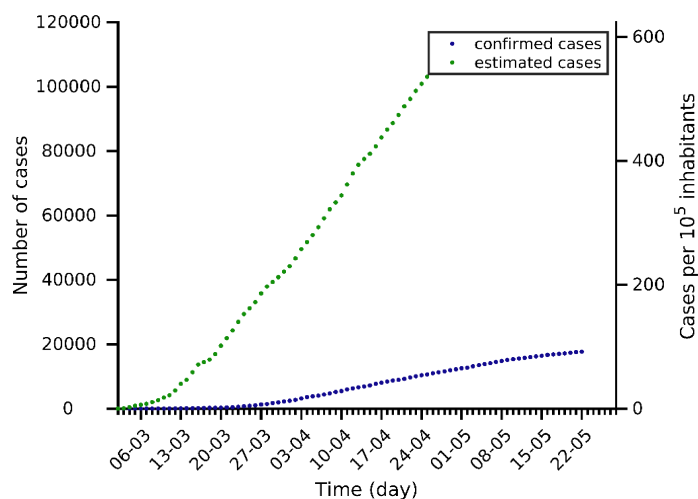
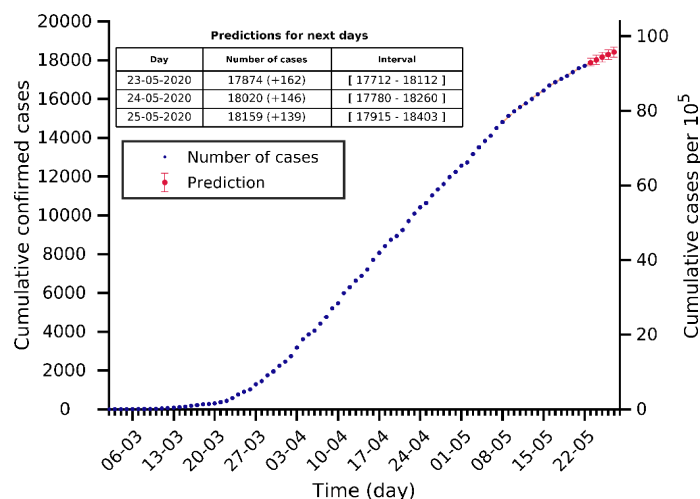
Ireland 22-05-2020. Population: 4.9M. Current cumulated incidence: 496/10⁵



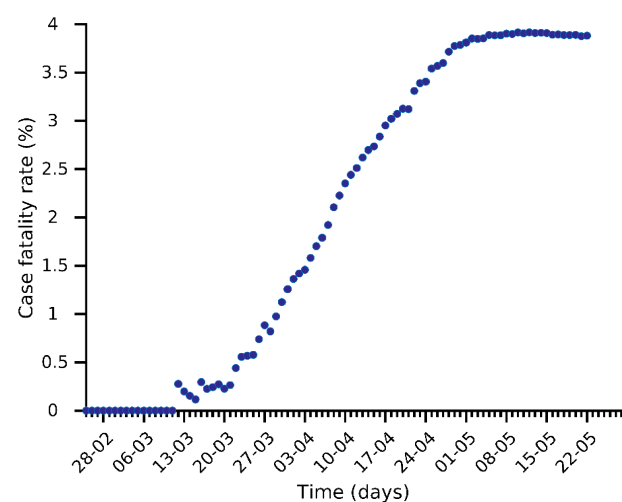
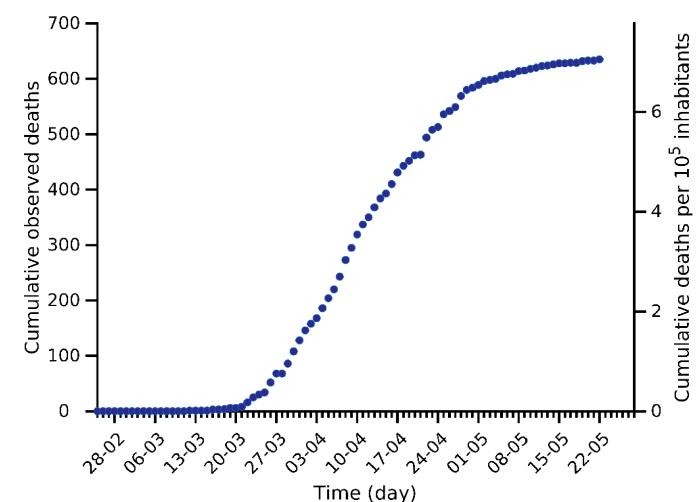
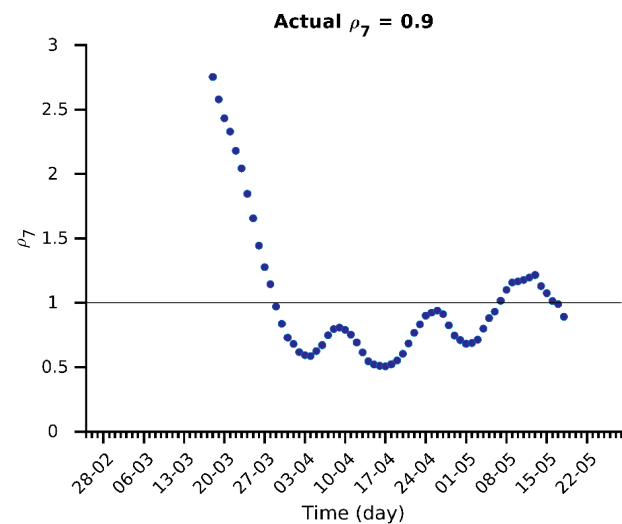
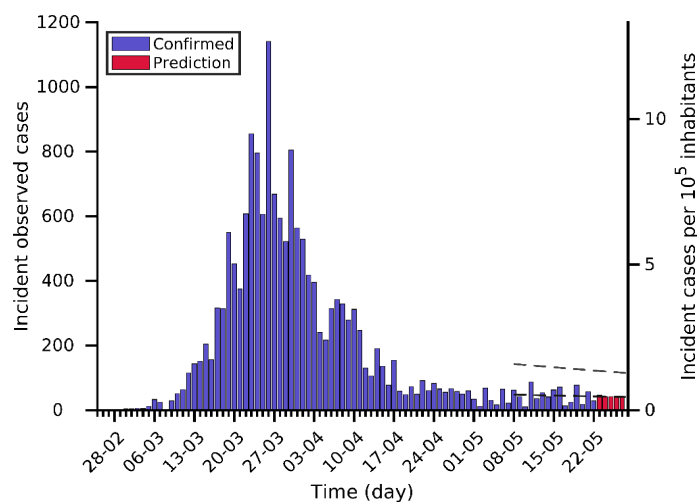
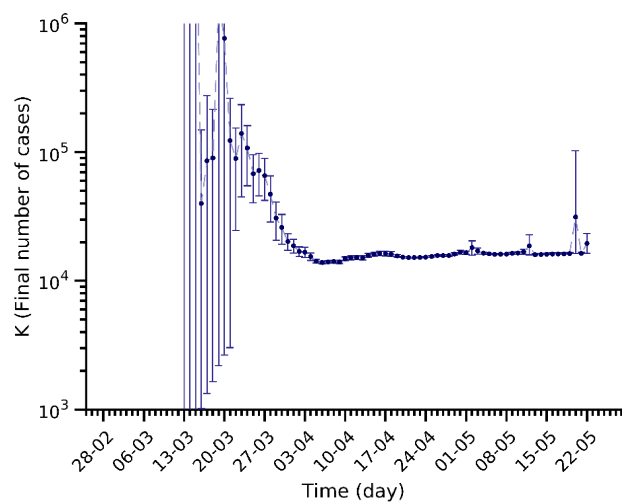
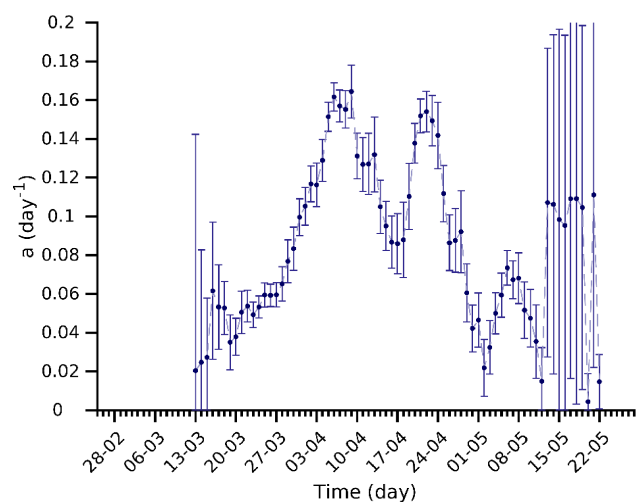
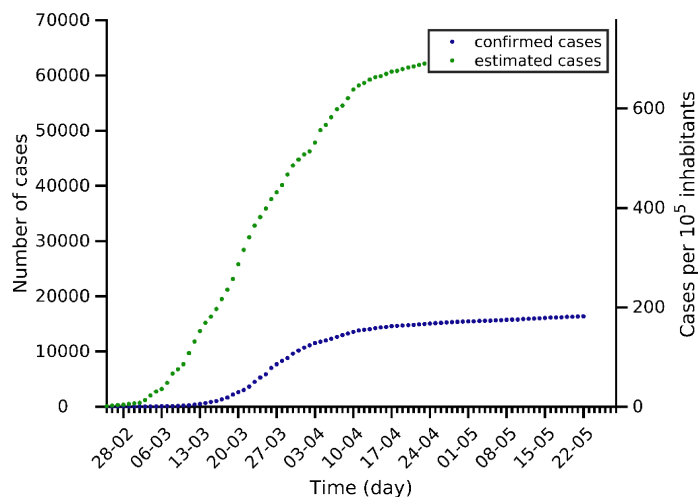
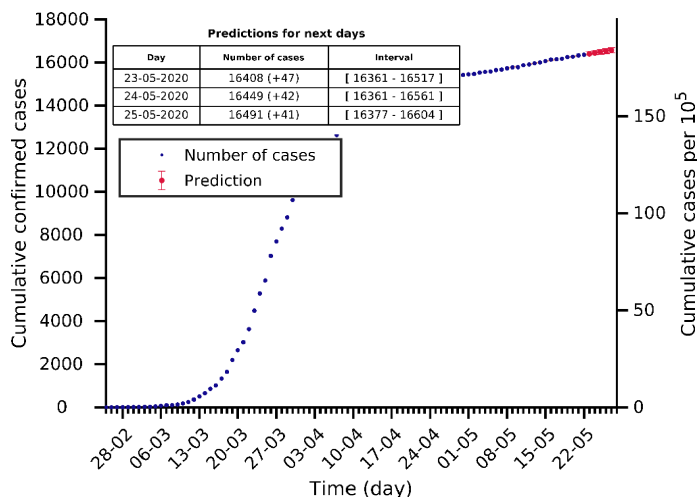
Poland 22-05-2020. Population: 37.8M. Current cumulated incidence: 54/10⁵



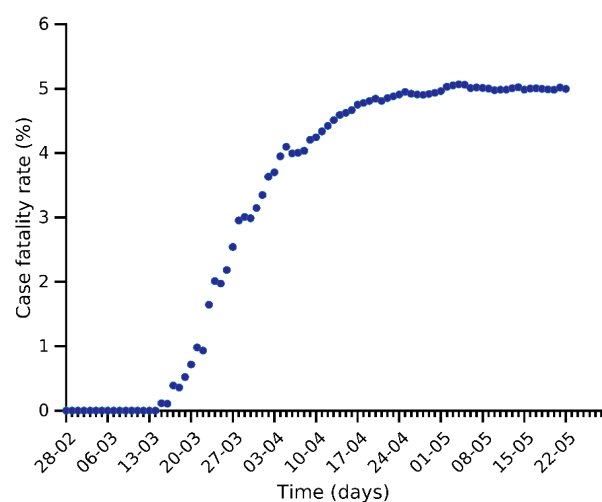
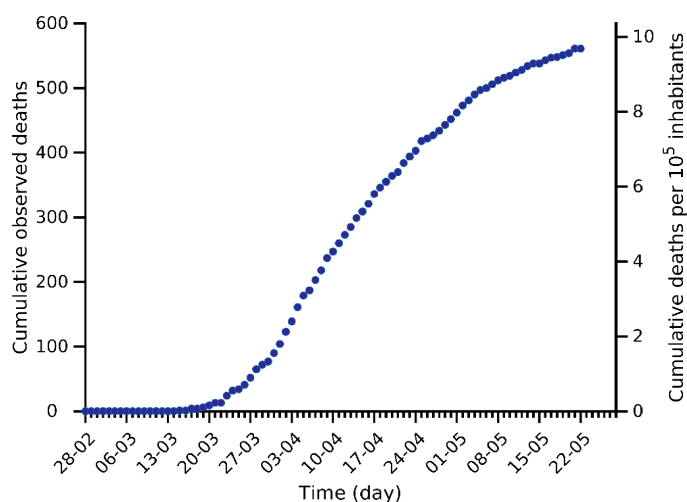
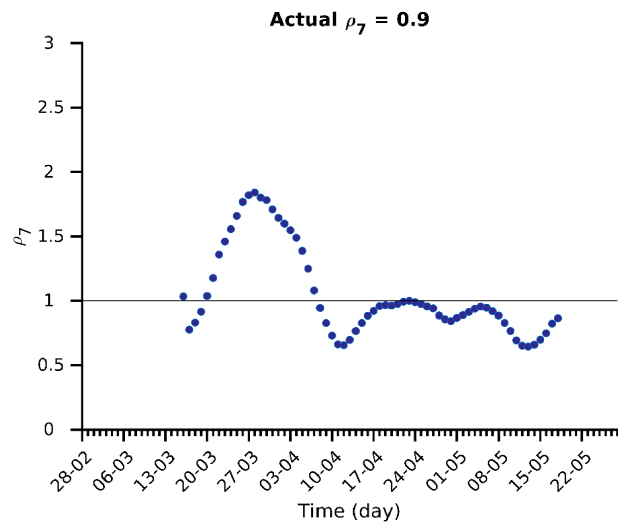
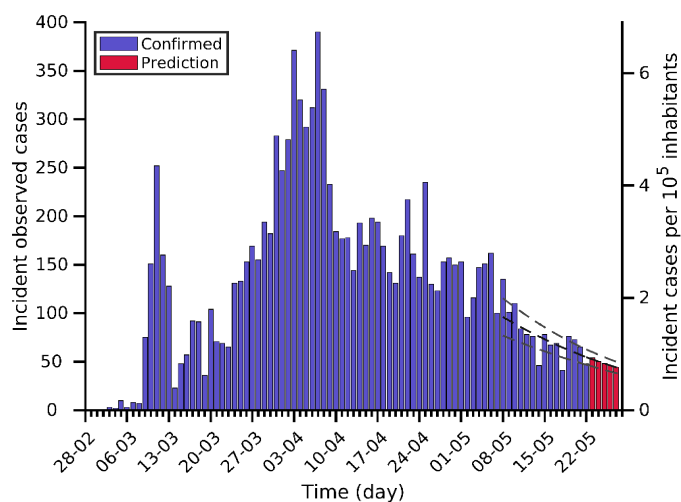
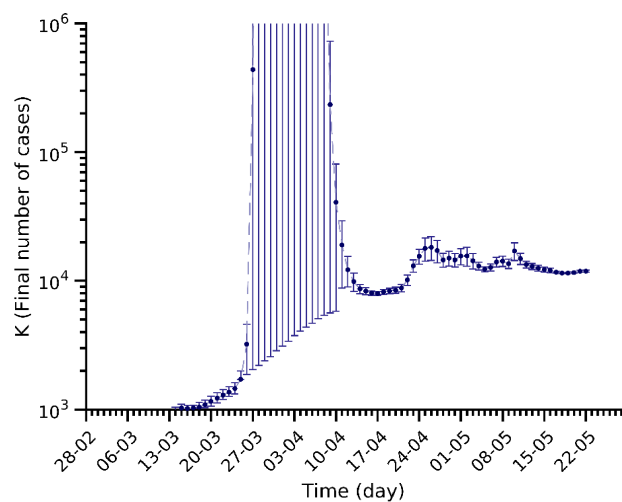
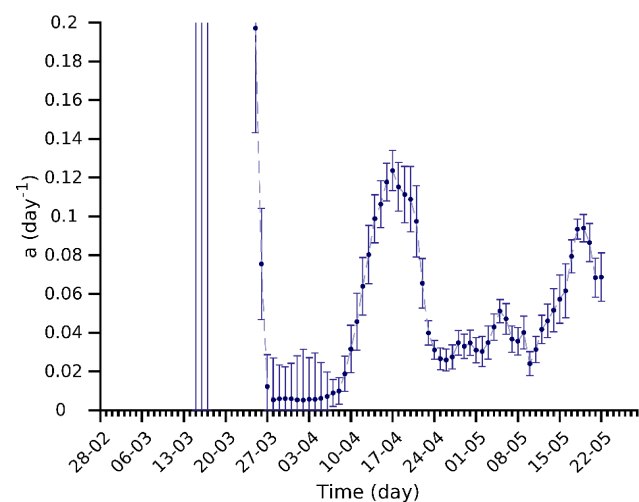
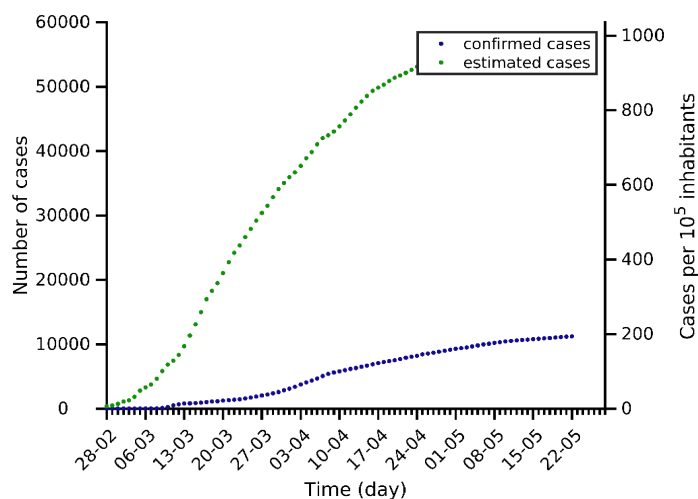
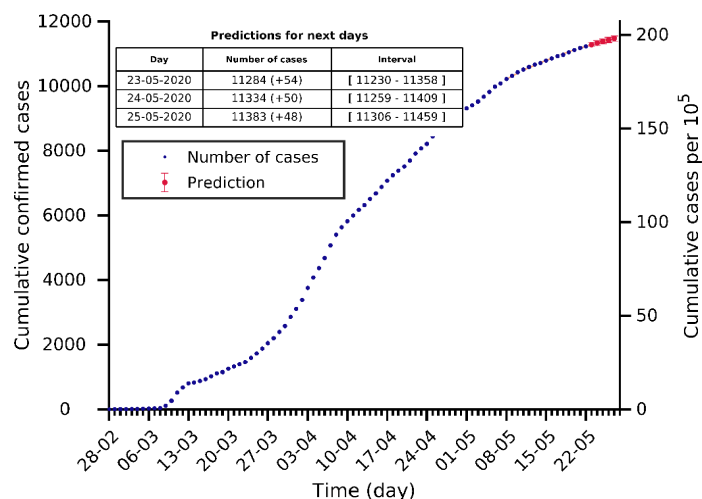
Romania 22-05-2020. Population: 19.2M. Current cumulated incidence: 92/10⁵



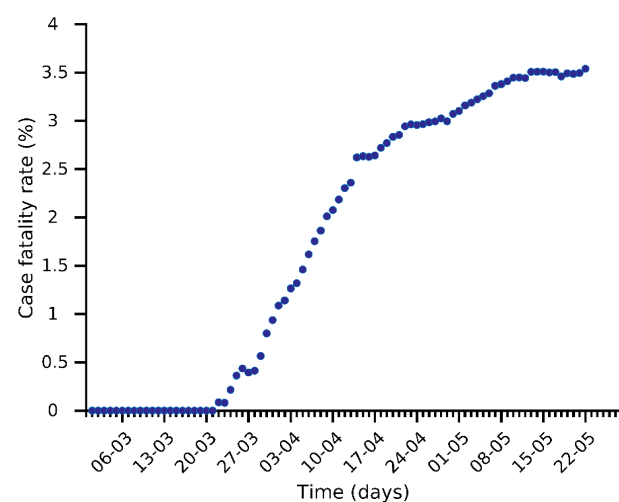
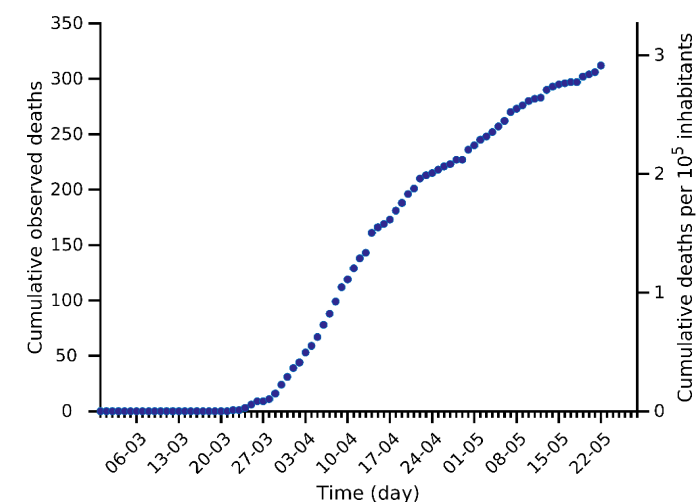
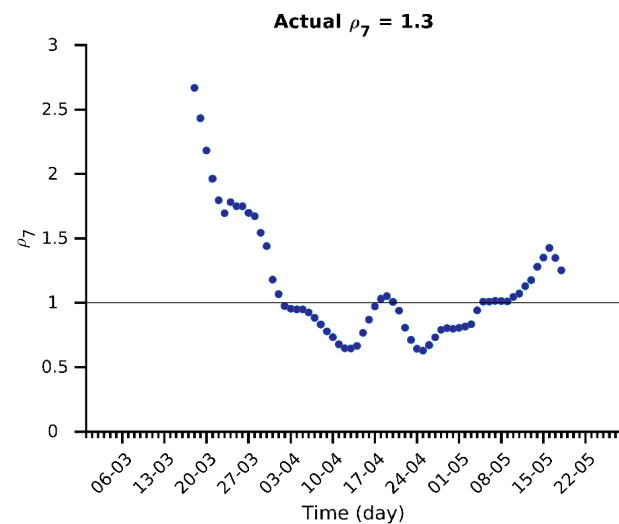
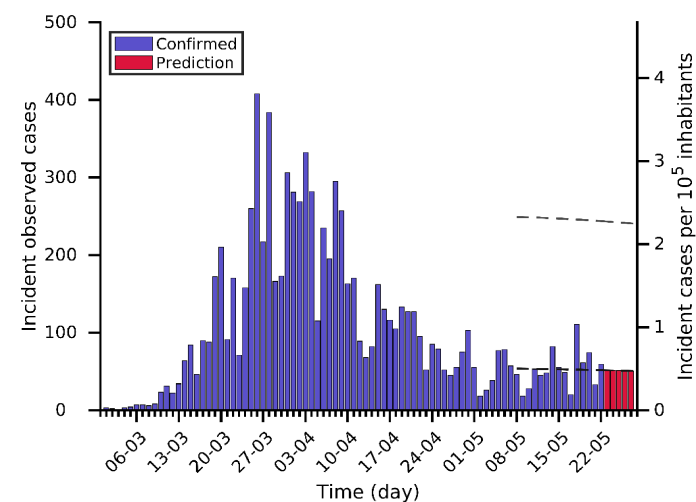
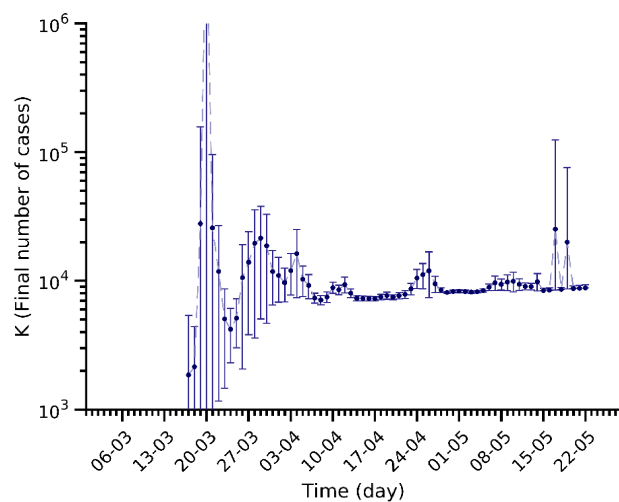
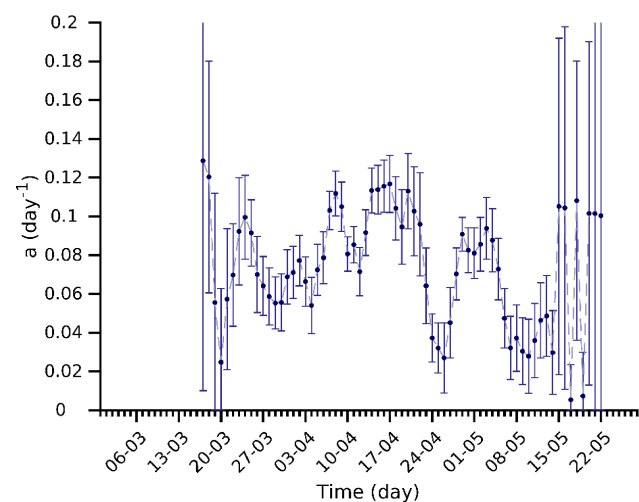
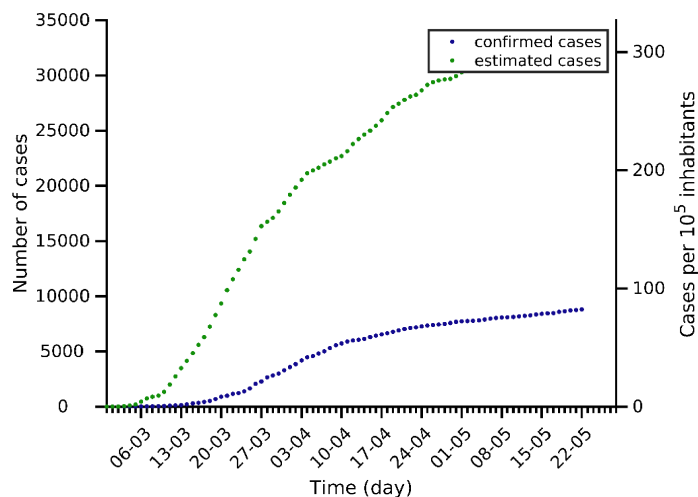
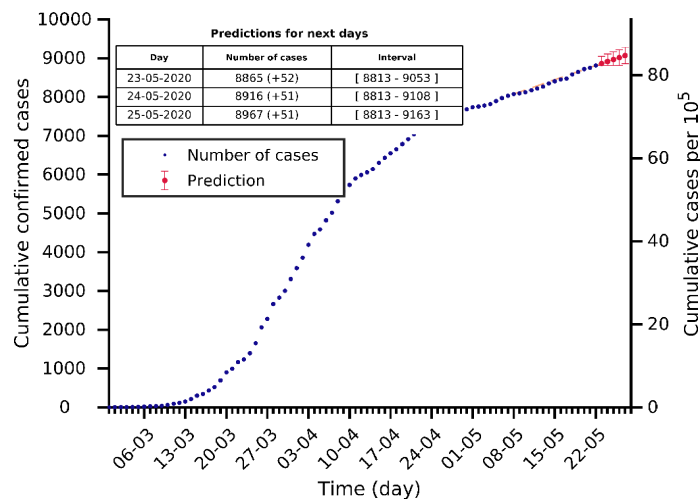
Austria 22-05-2020. Population: 9.0M. Current cumulated incidence: 182/10⁵



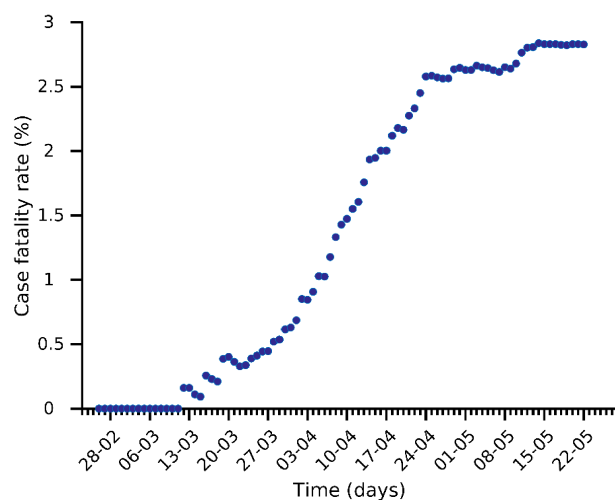
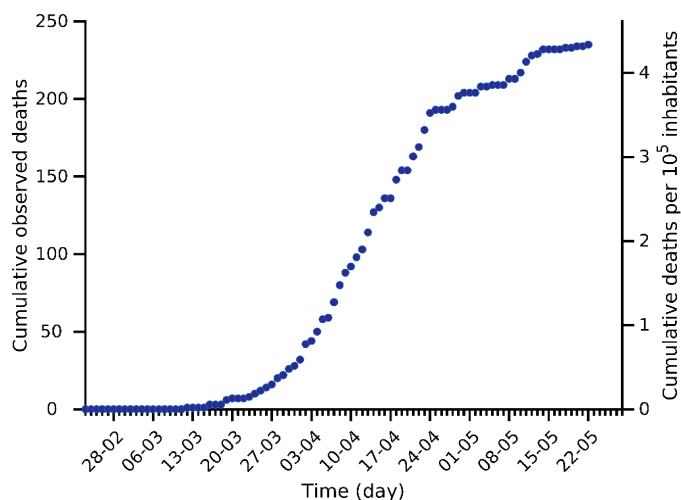
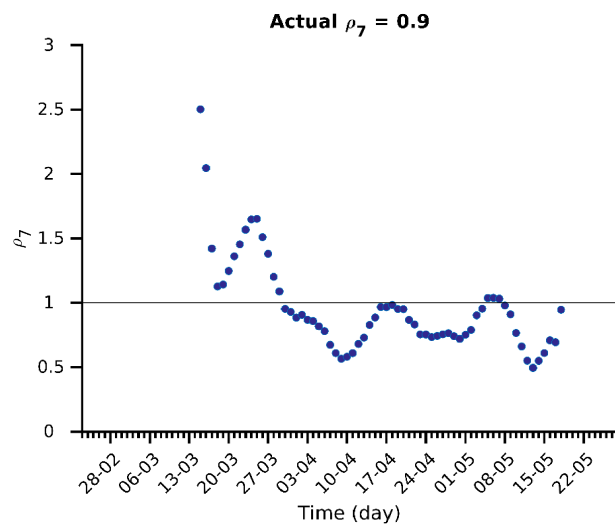
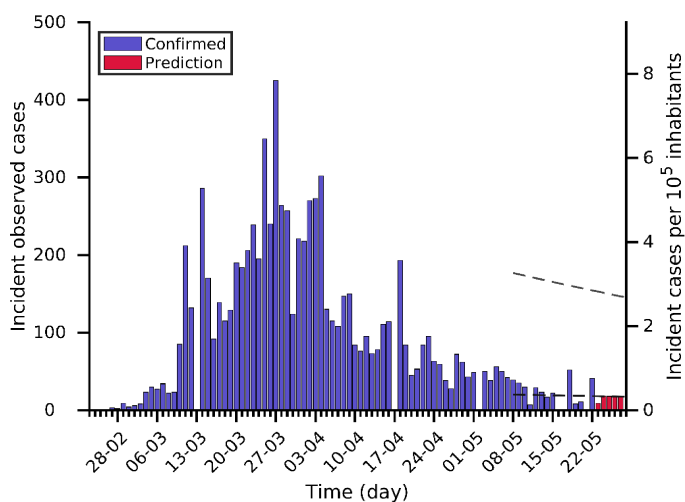
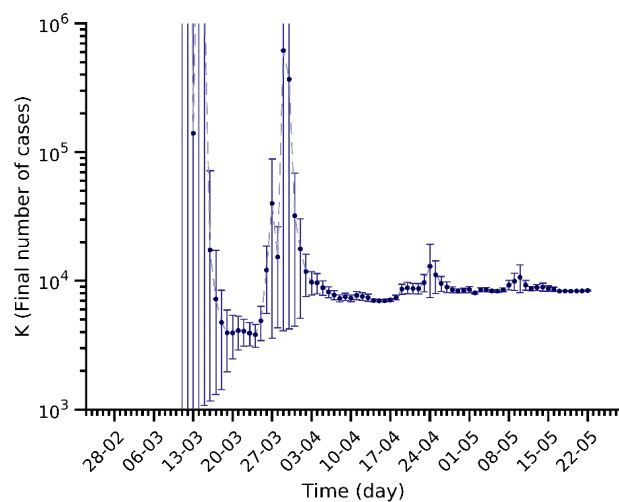
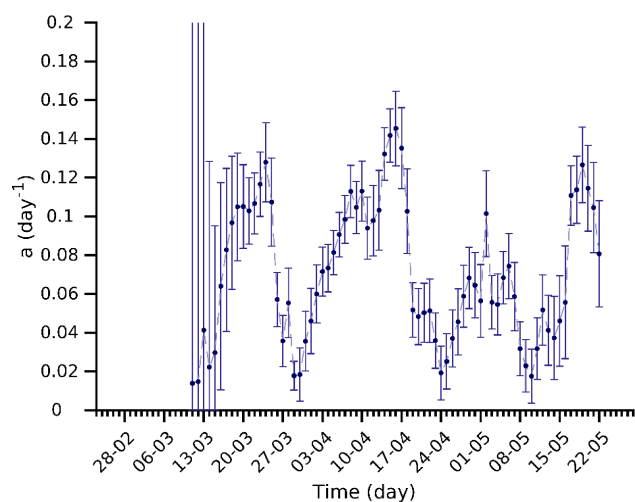
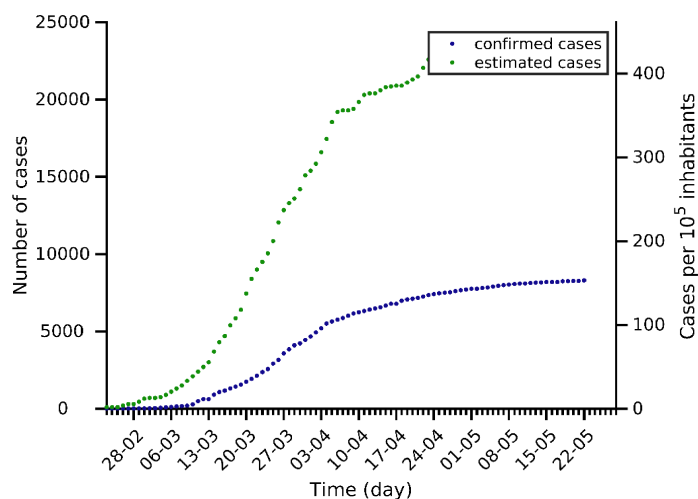
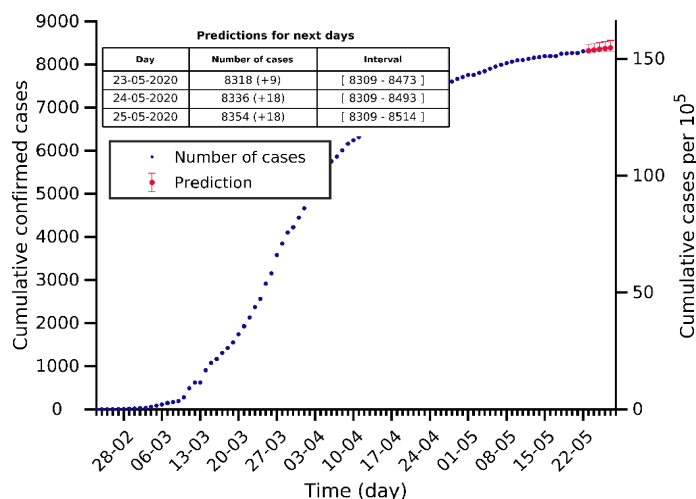
Denmark 22-05-2020. Population: 5.8M. Current cumulated incidence: 194/10⁵



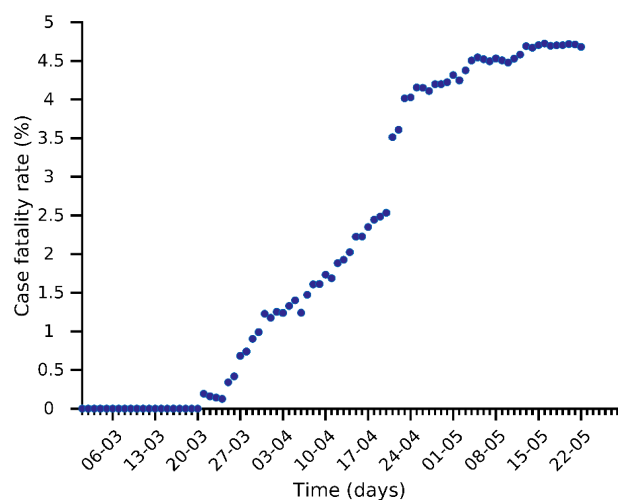
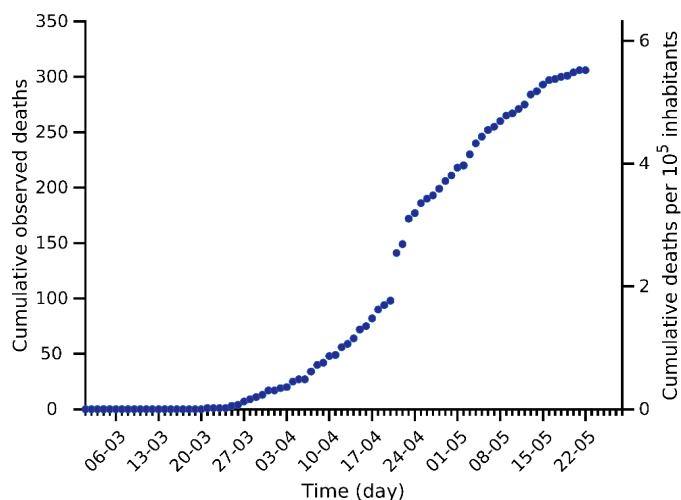
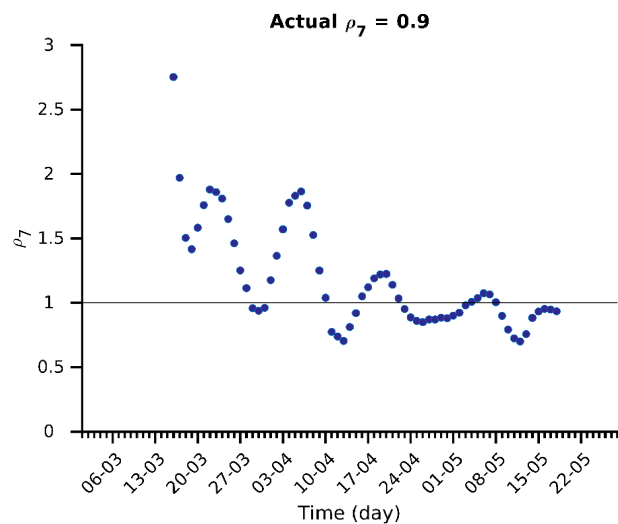
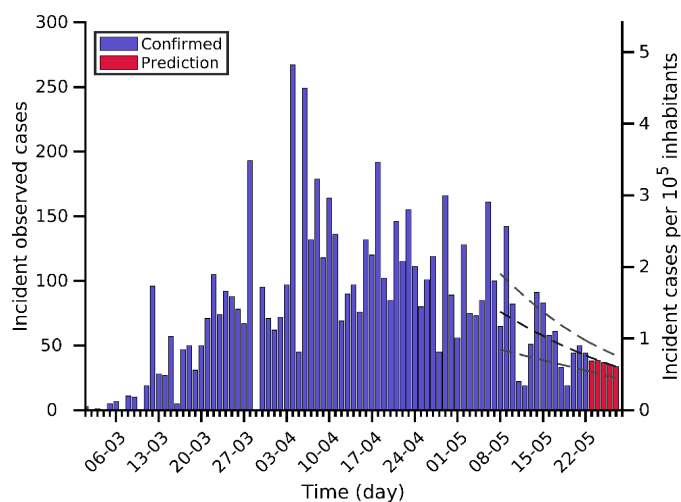
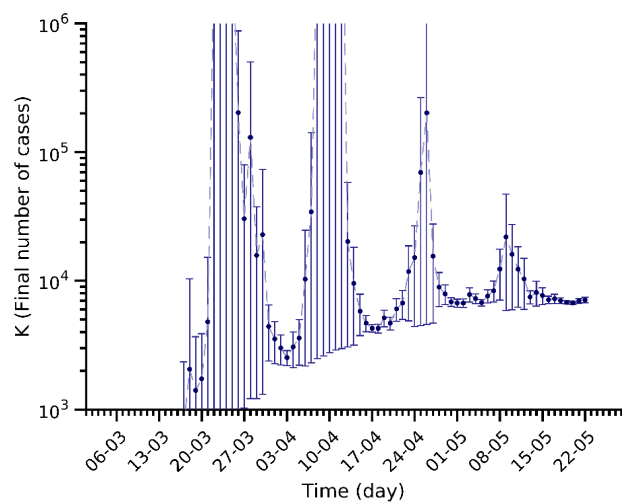
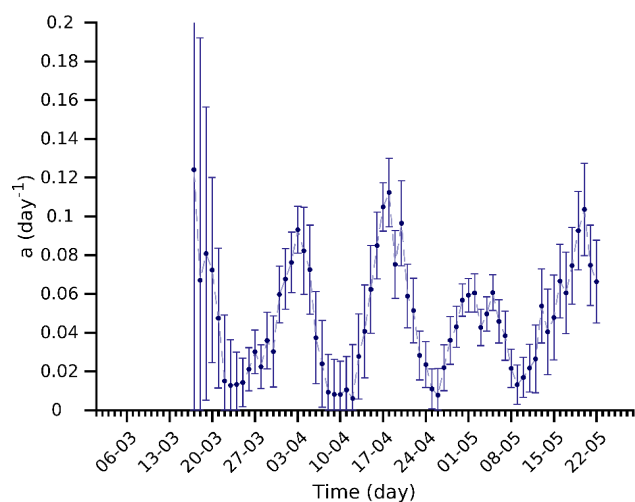
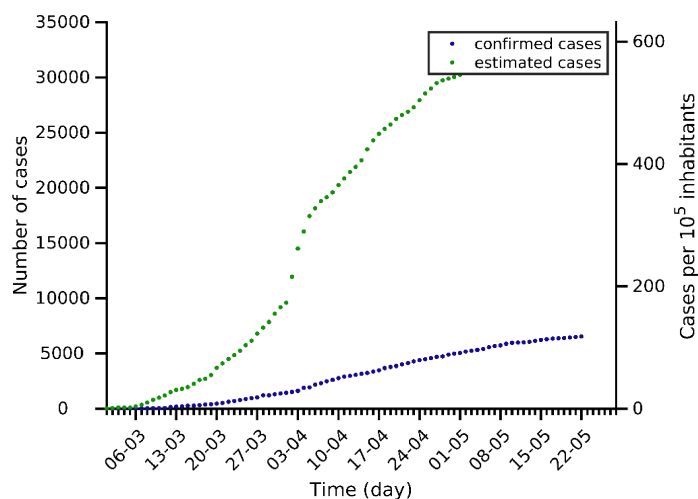
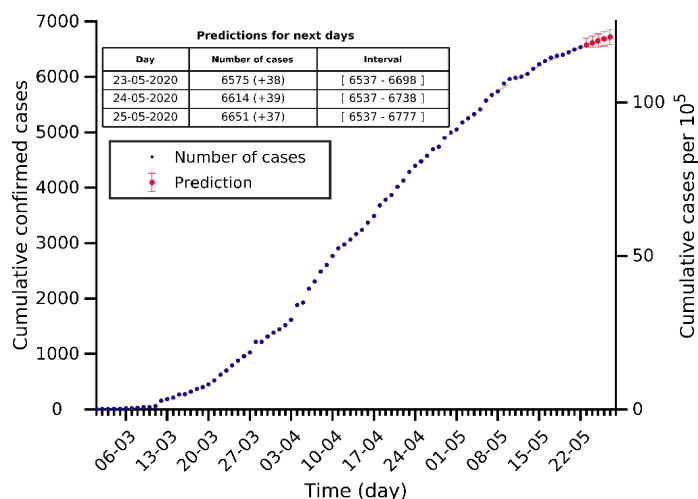
Czech Rep 22-05-2020. Population: 10.7M. Current cumulated incidence: 82/10⁵



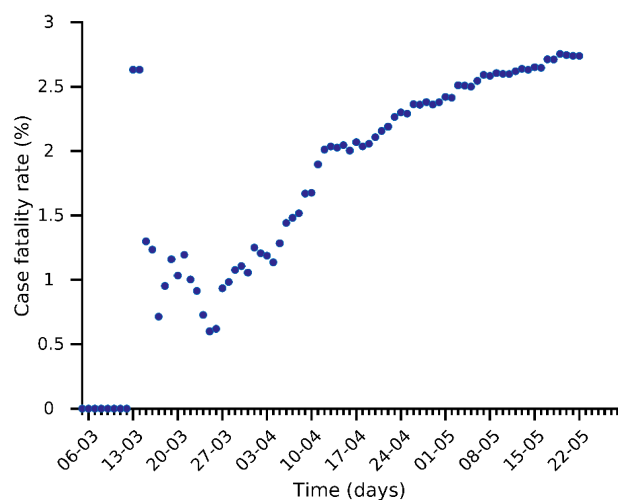
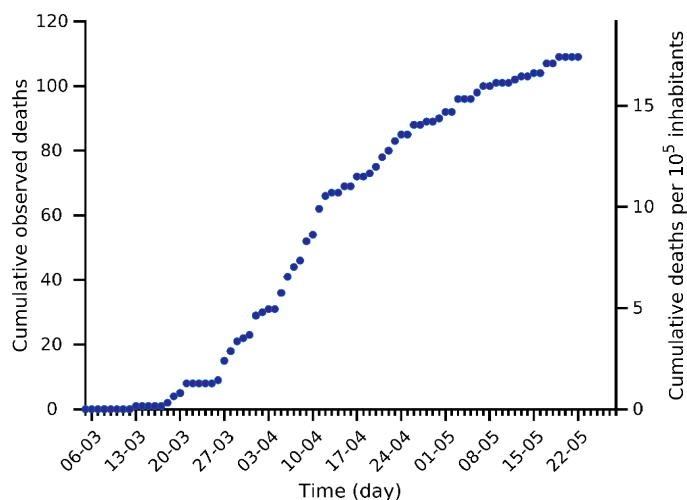
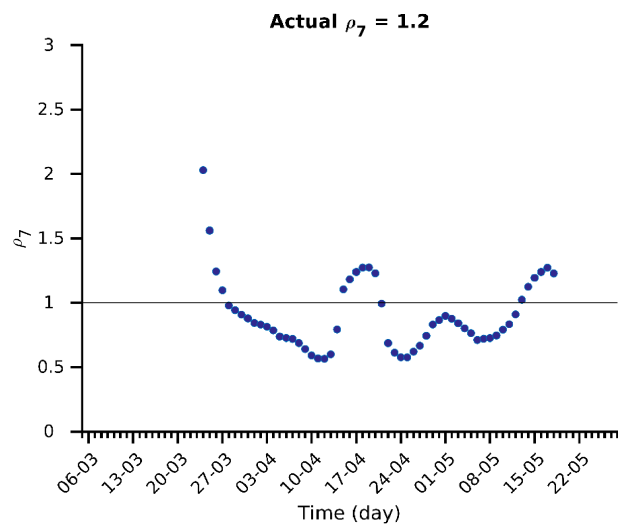
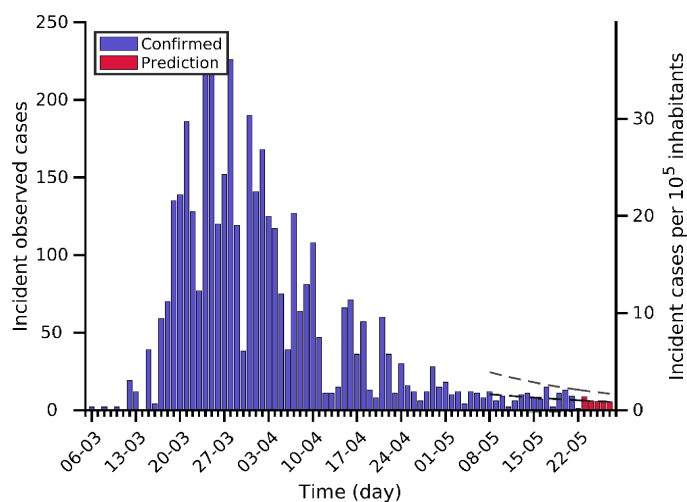
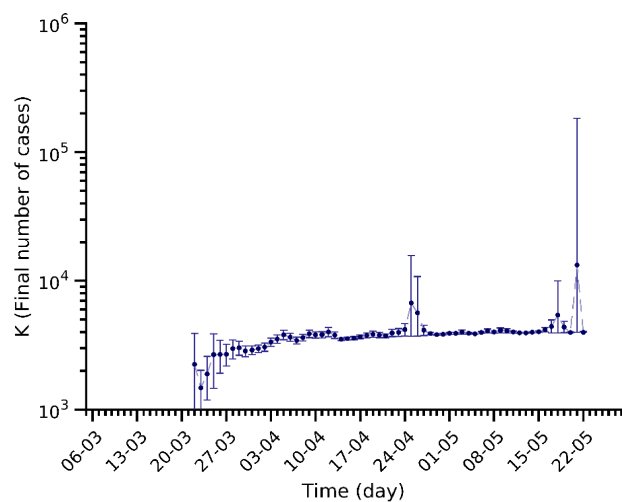
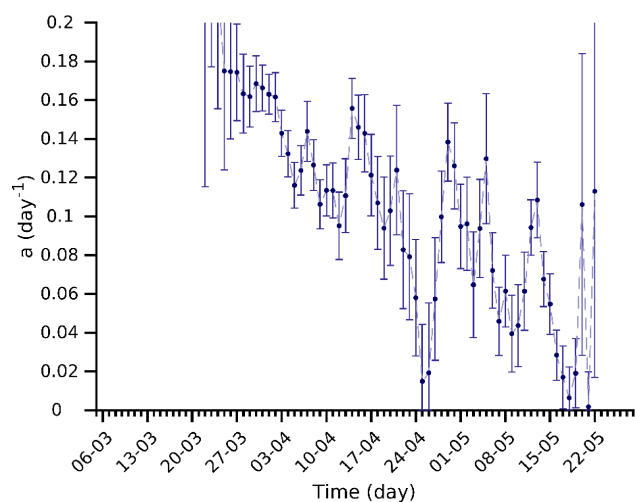
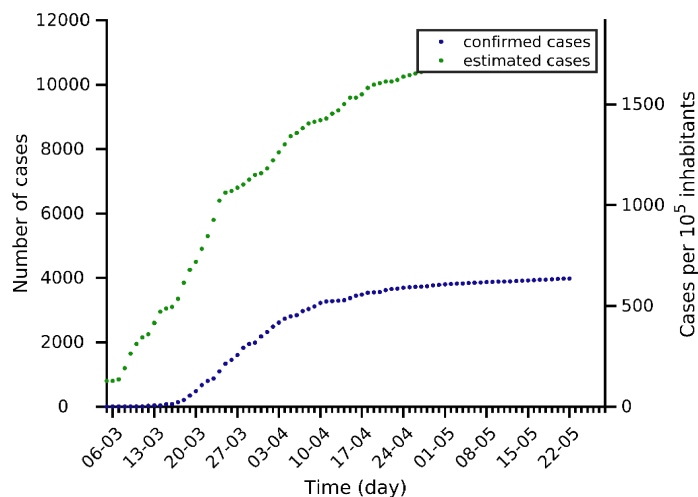
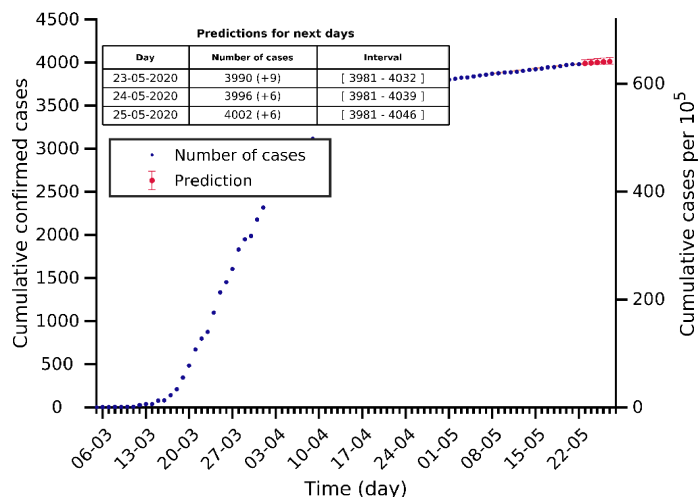
Norway 22-05-2020. Population: 5.4M. Current cumulated incidence: 153/10⁵



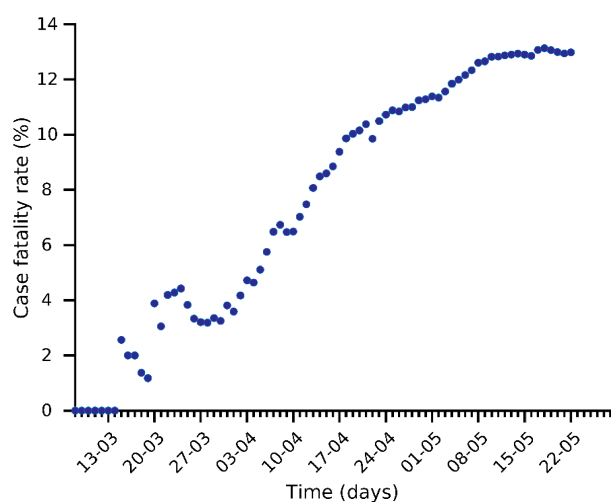
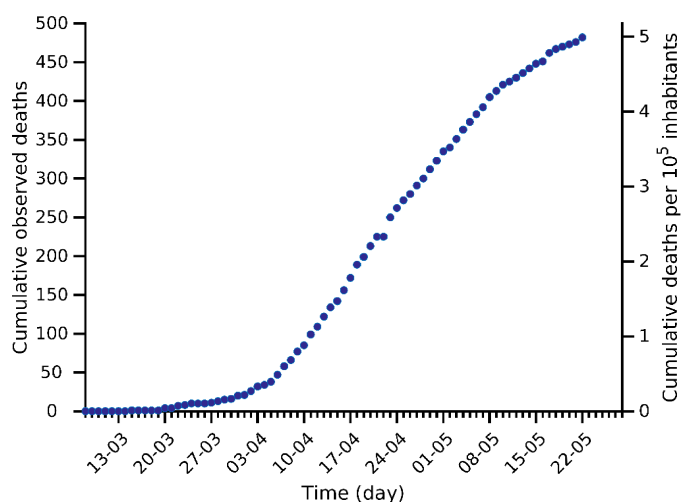
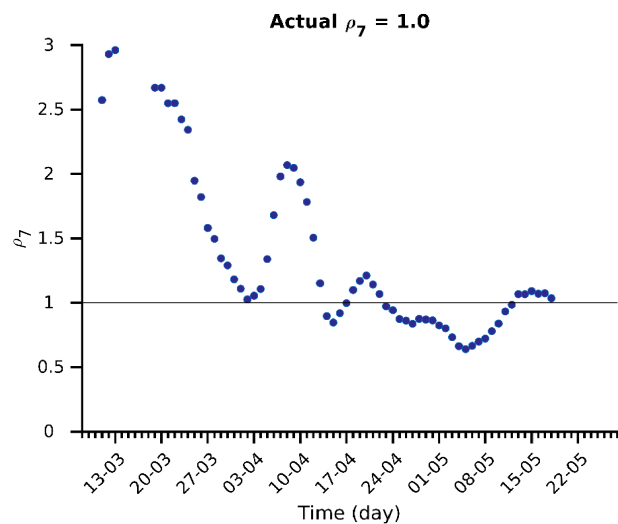
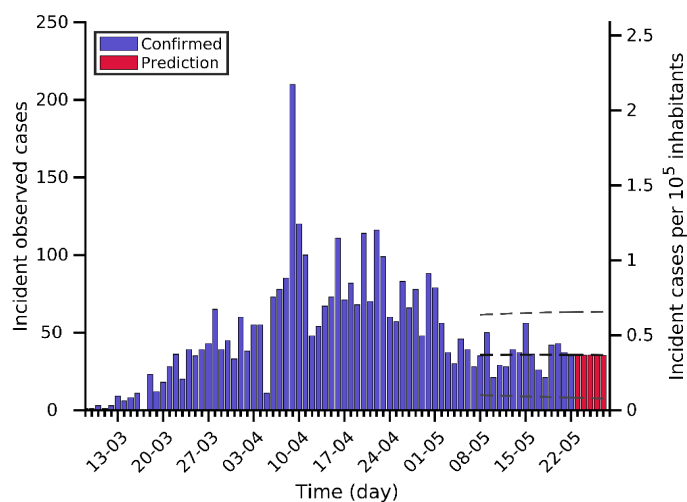
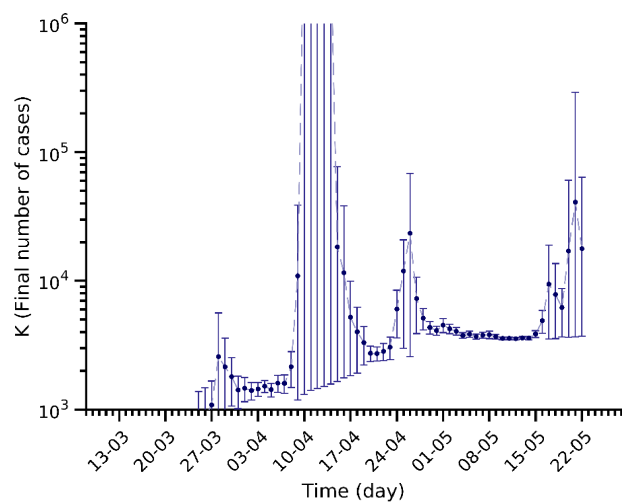
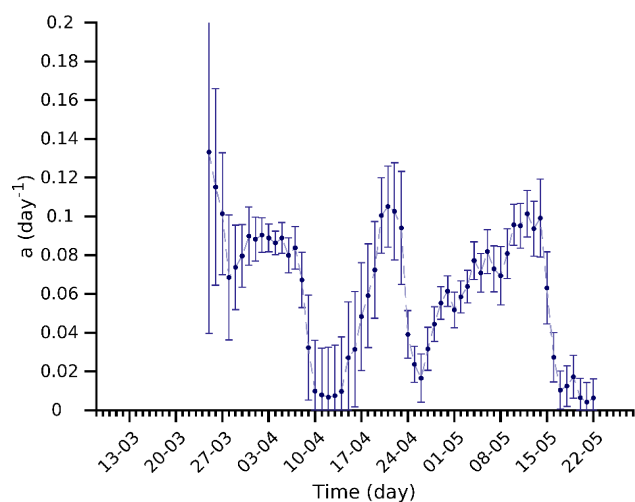
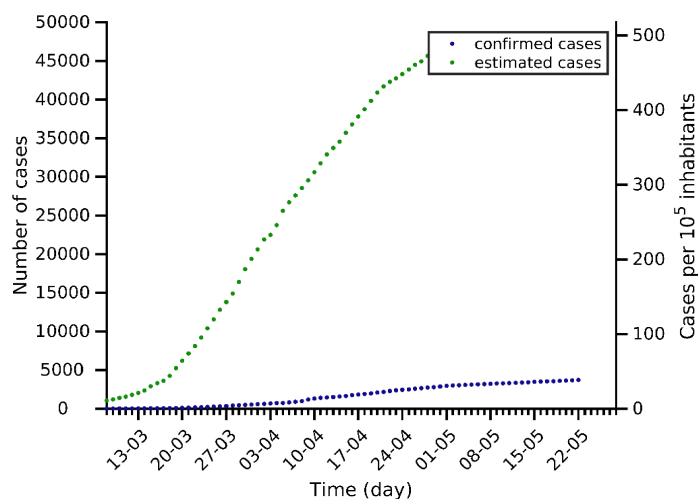
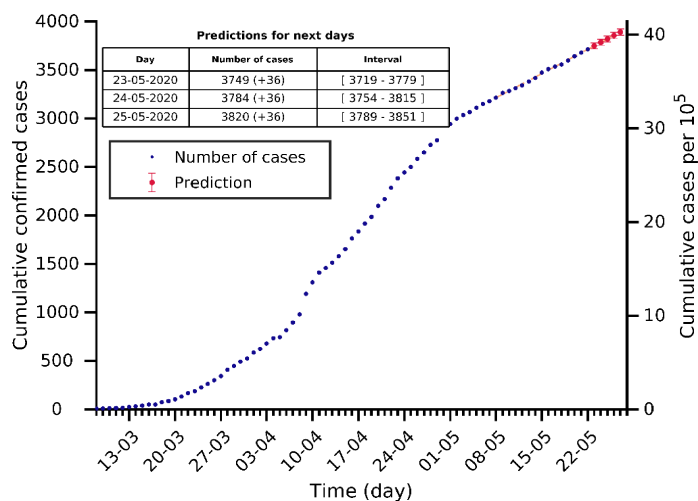
Finland 22-05-2020. Population: 5.5M. Current cumulated incidence: 118/10⁵



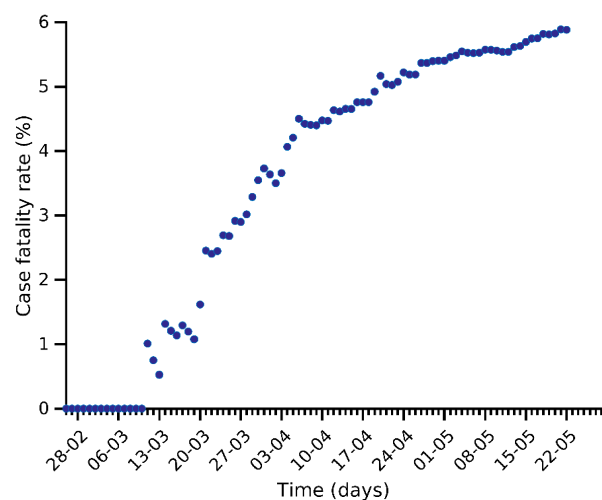
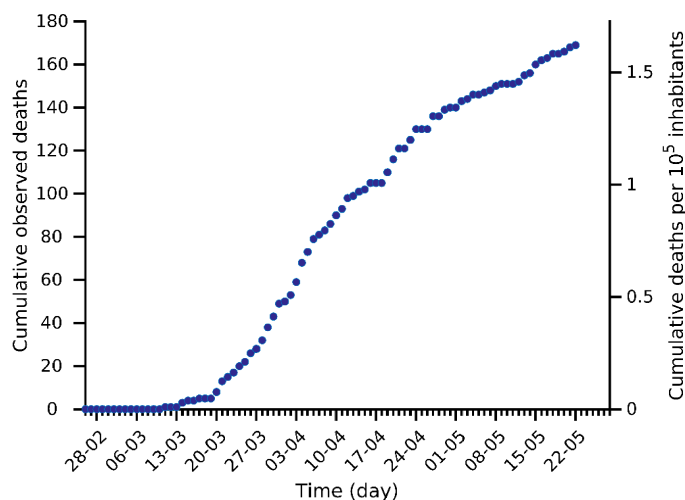
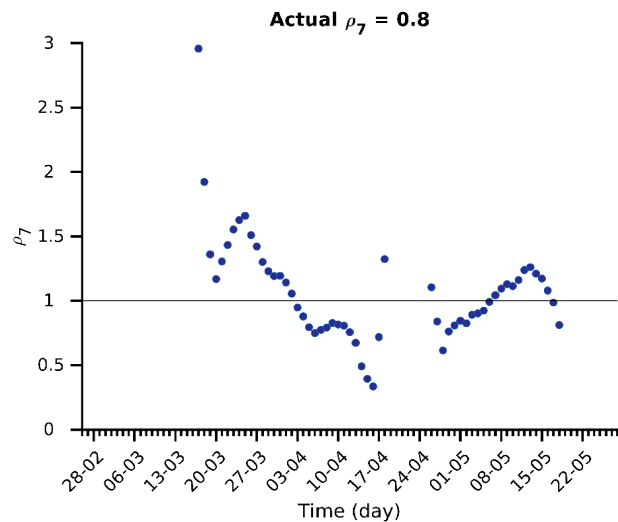
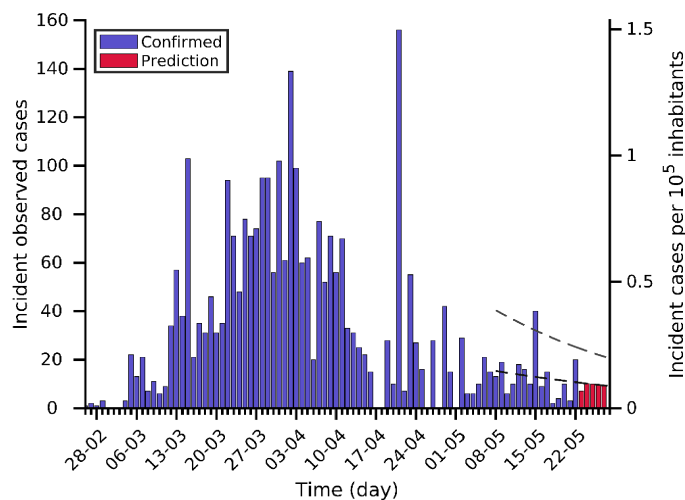
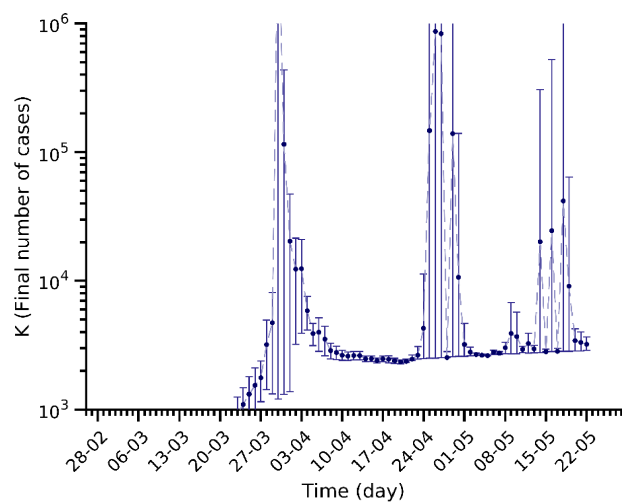
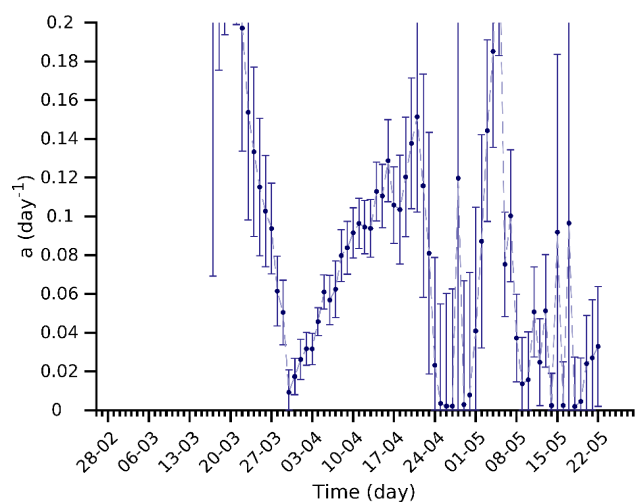
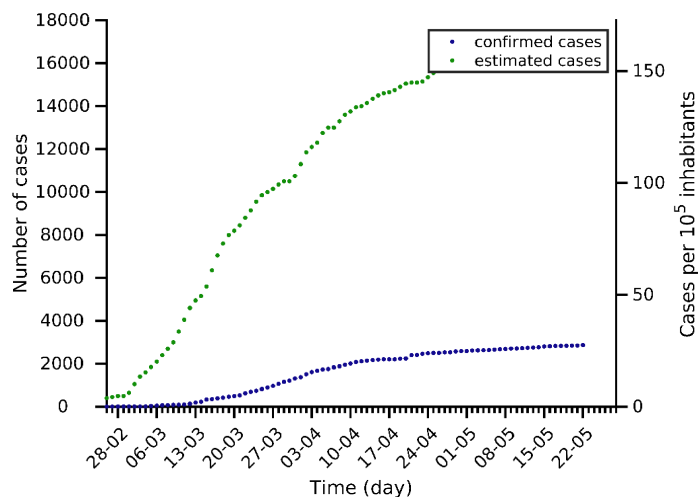
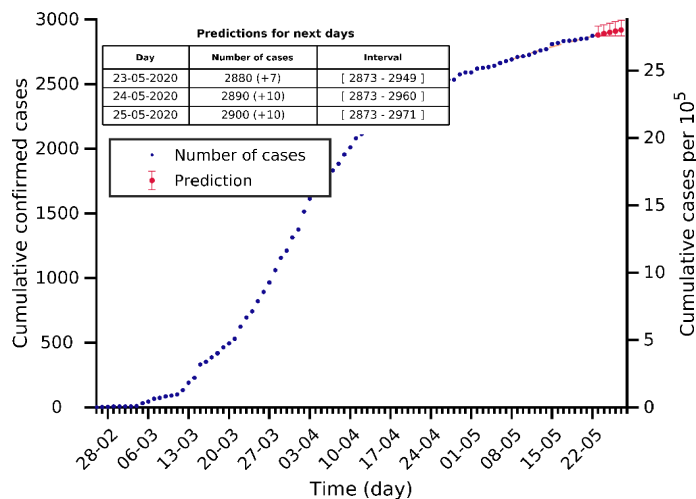
Luxembourg 22-05-2020. Population: 0.6M. Current cumulated incidence: 636/10⁵



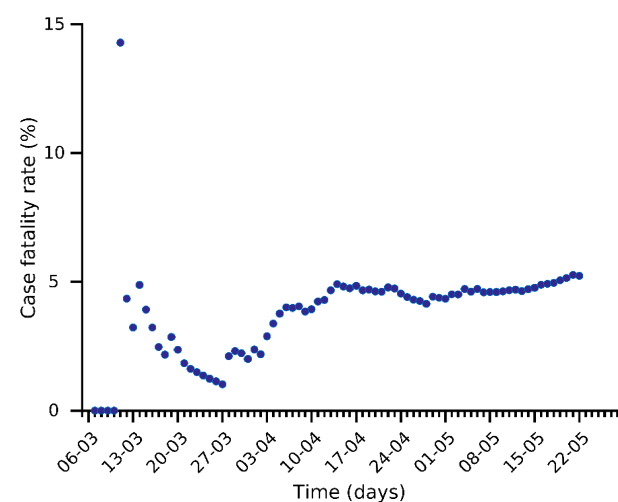
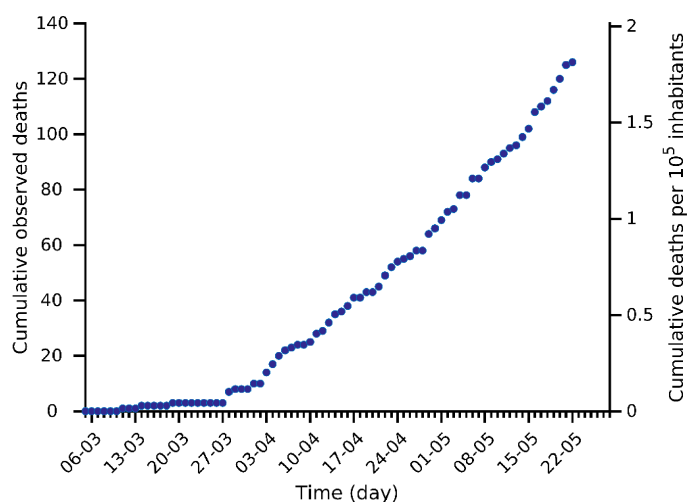
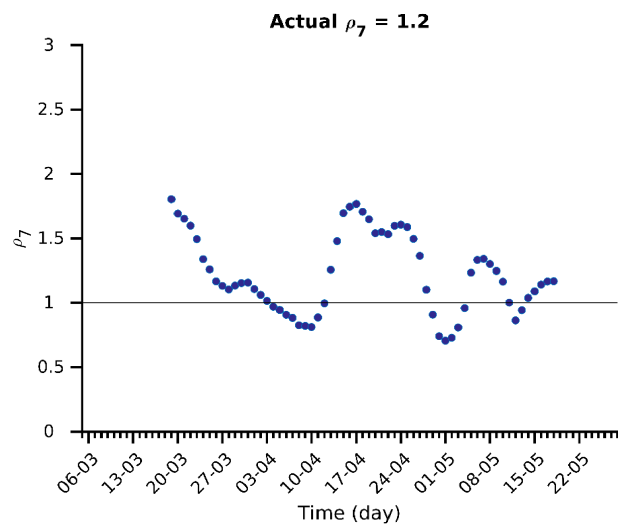
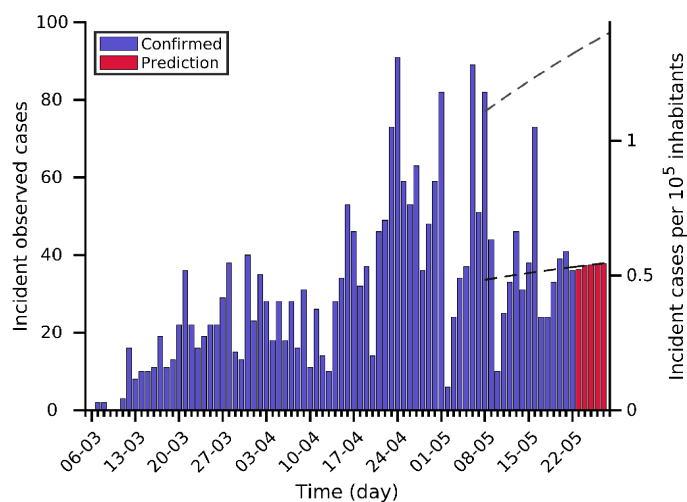
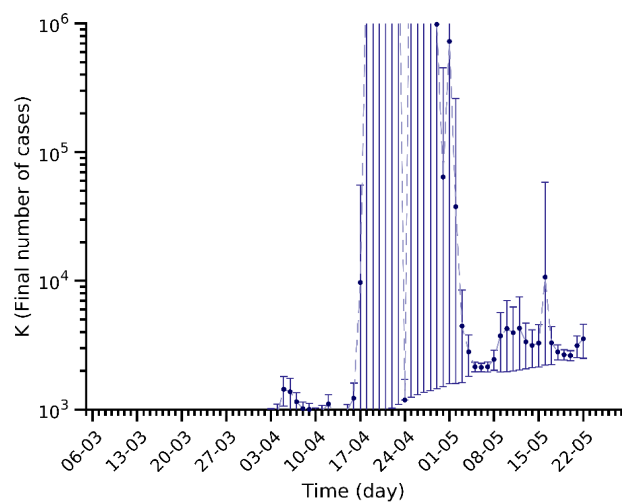
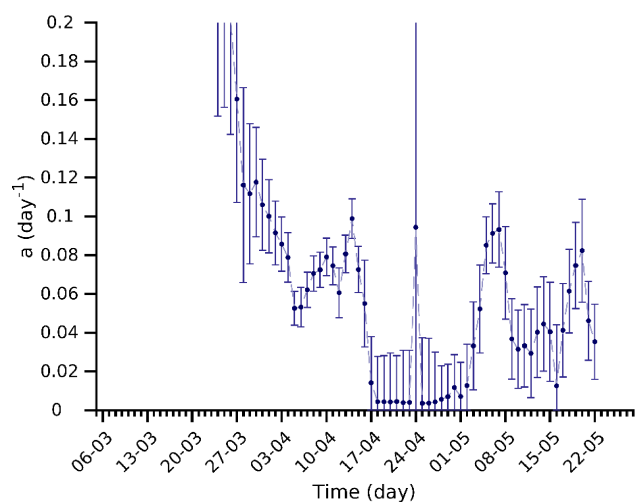
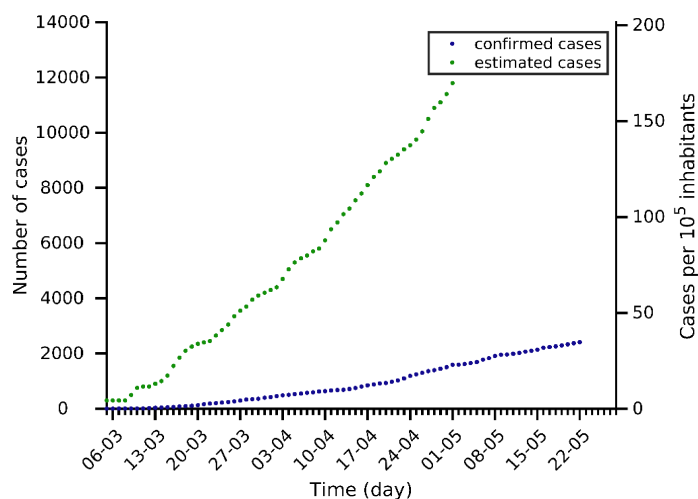
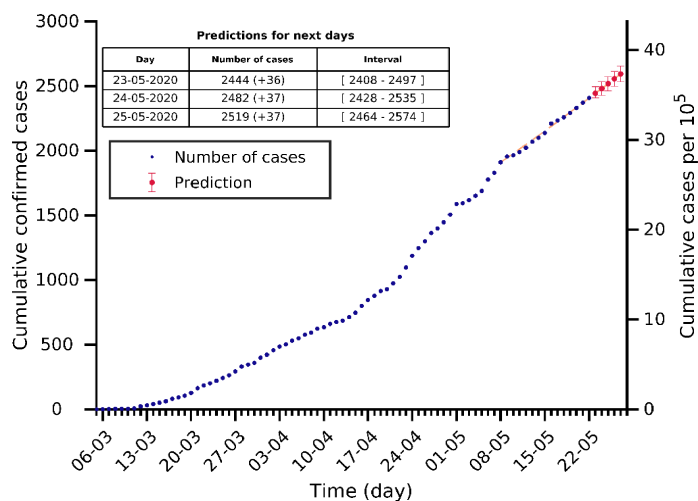
Hungary 22-05-2020. Population: 9.7M. Current cumulated incidence: 38/10⁵



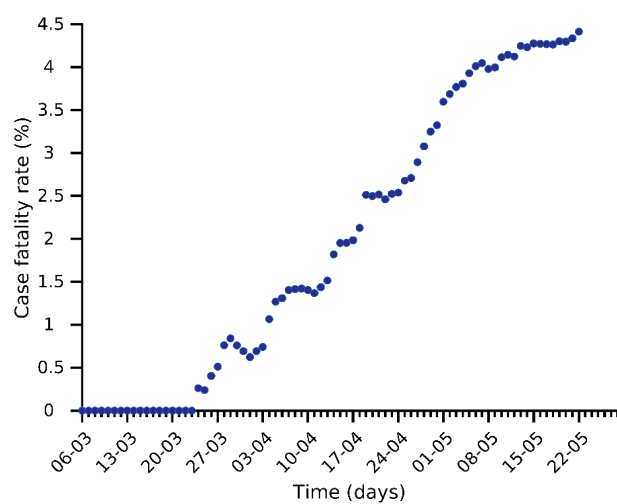
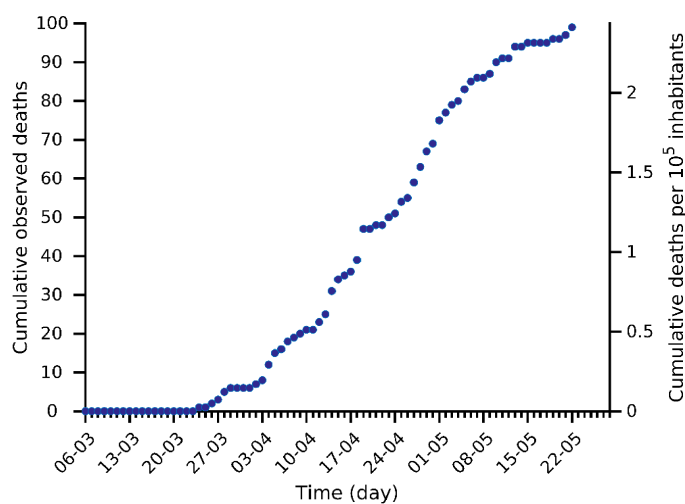
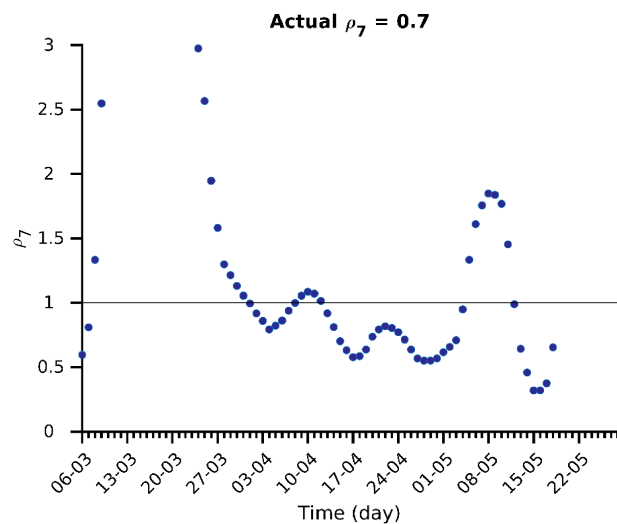
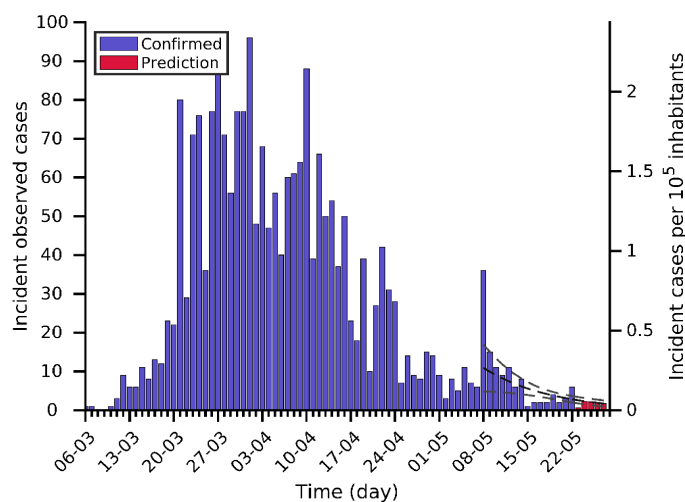
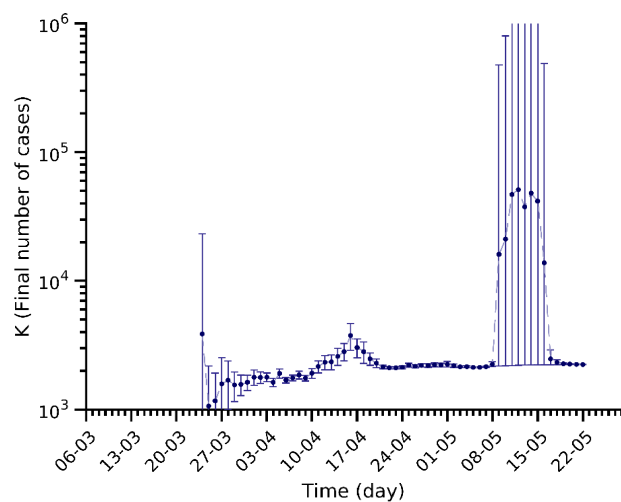
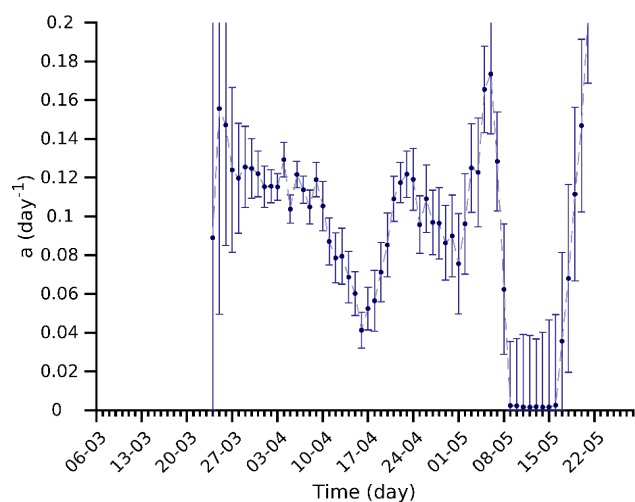
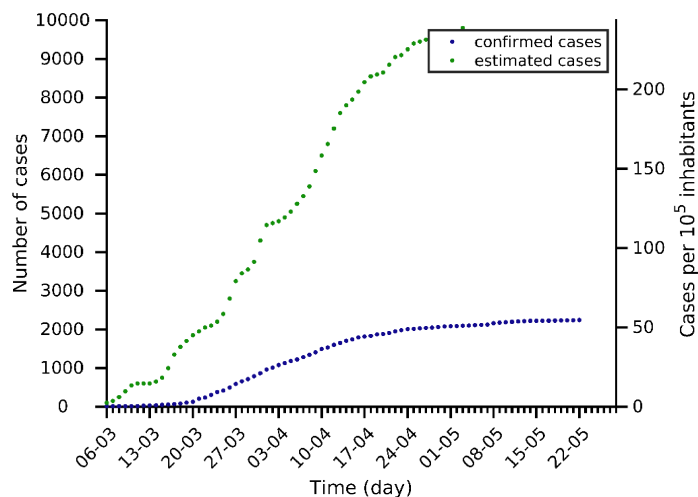
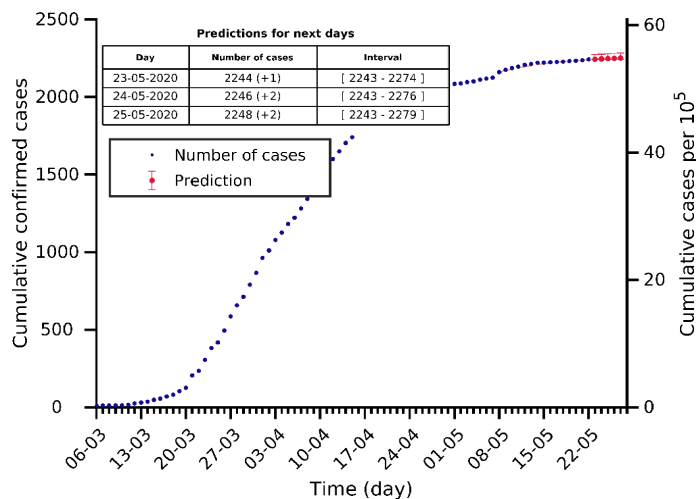
Greece 22-05-2020. Population: 10.4M. Current cumulated incidence: 28/10⁵



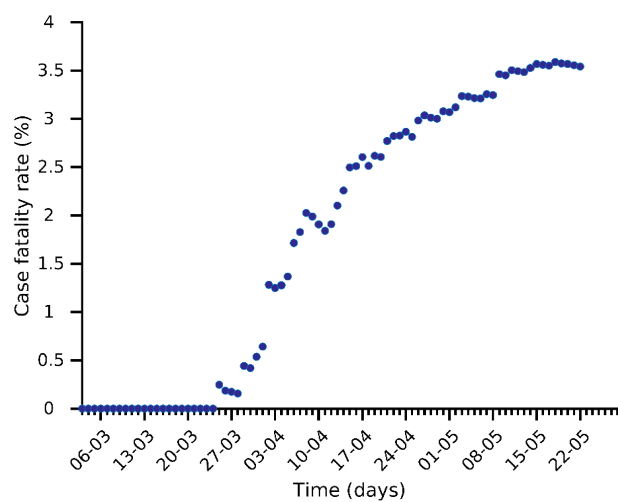
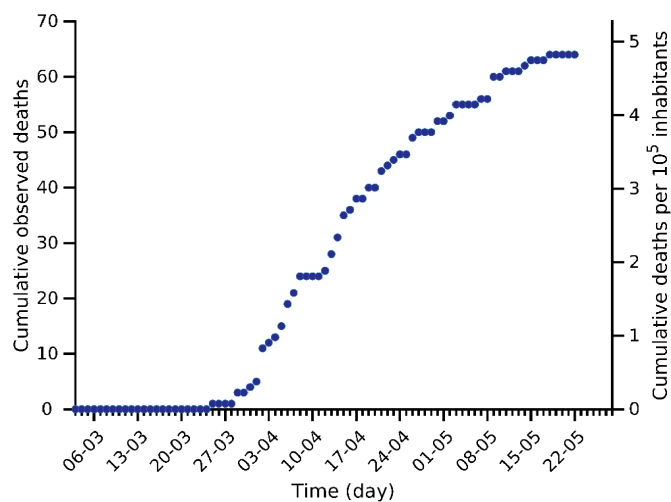
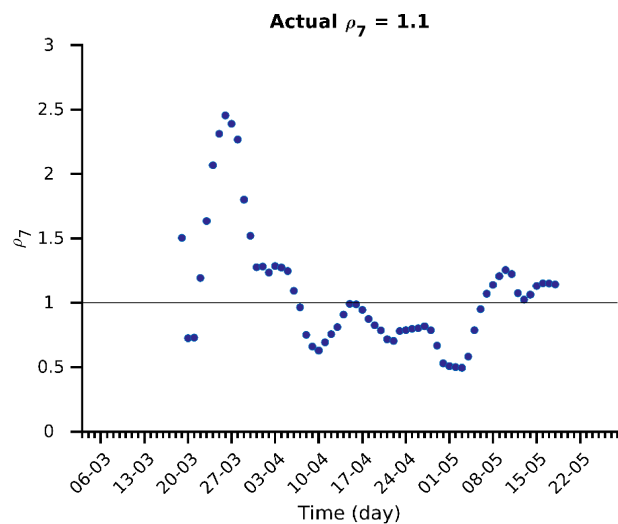
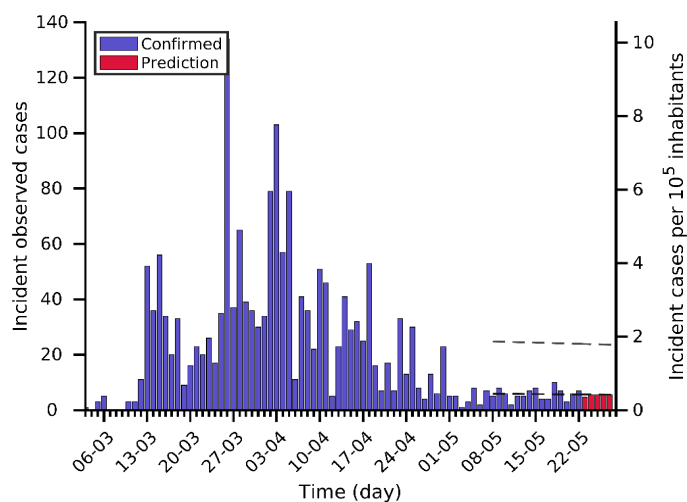
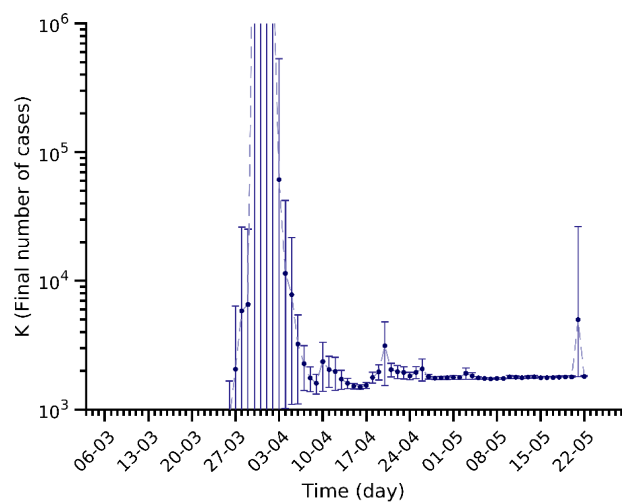
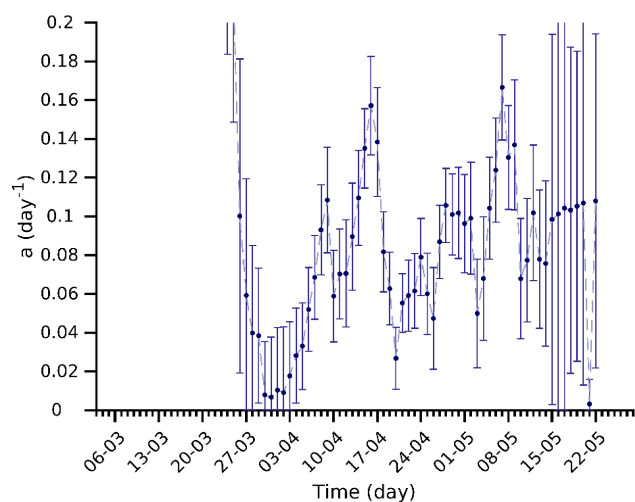
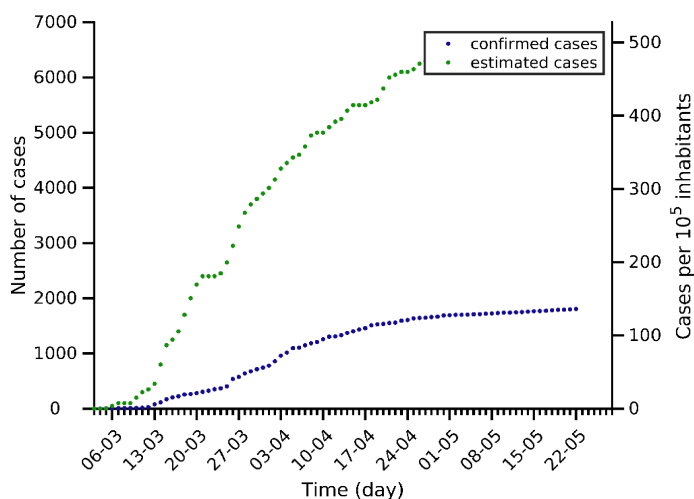
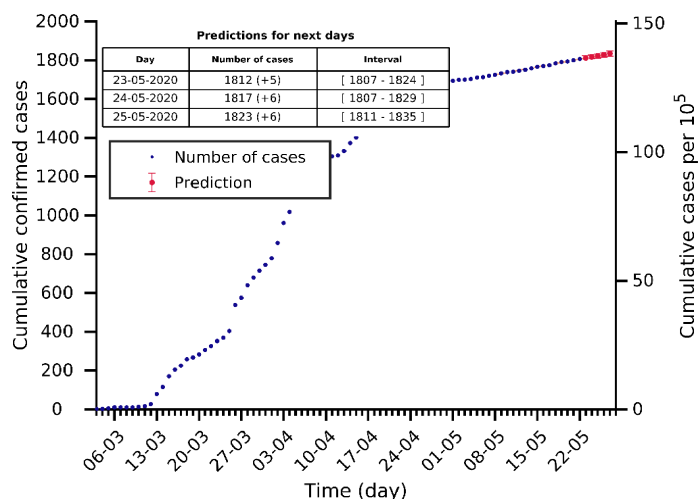
Bulgaria 22-05-2020. Population: 6.9M. Current cumulated incidence: 35/10⁵



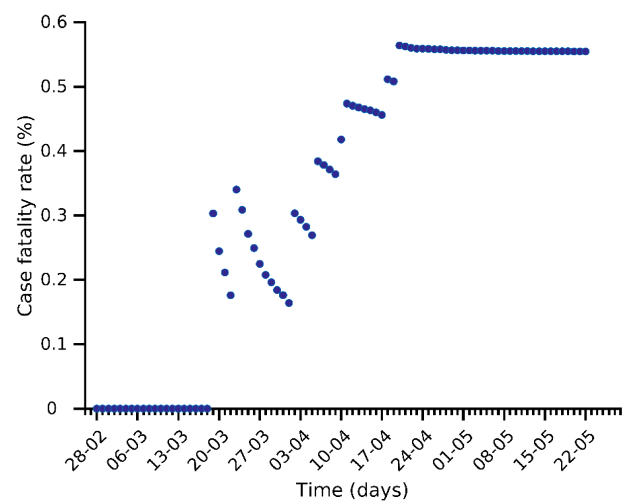
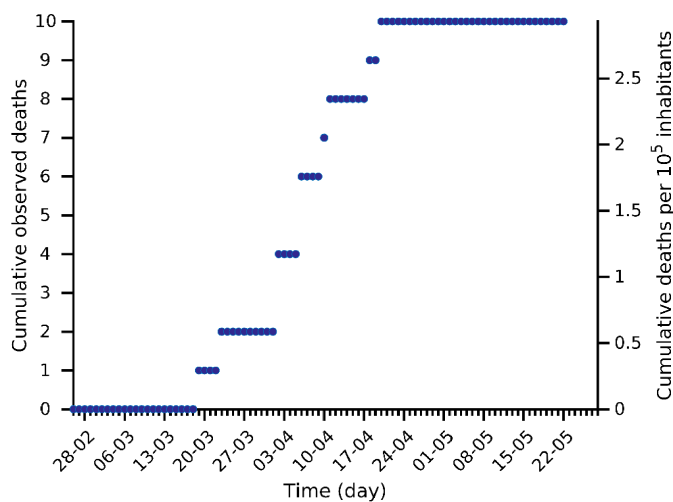
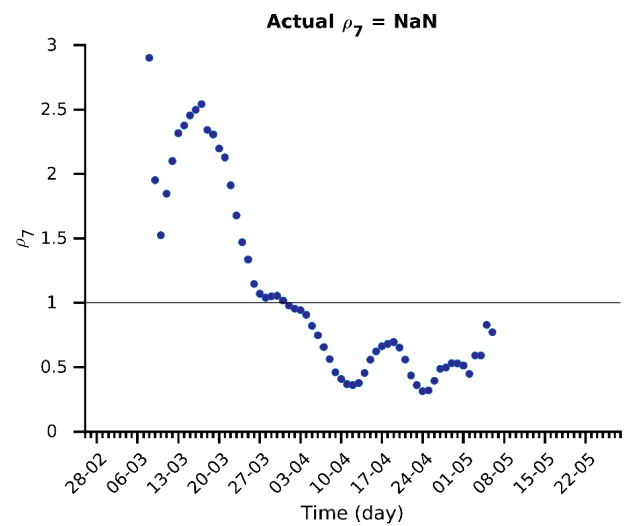
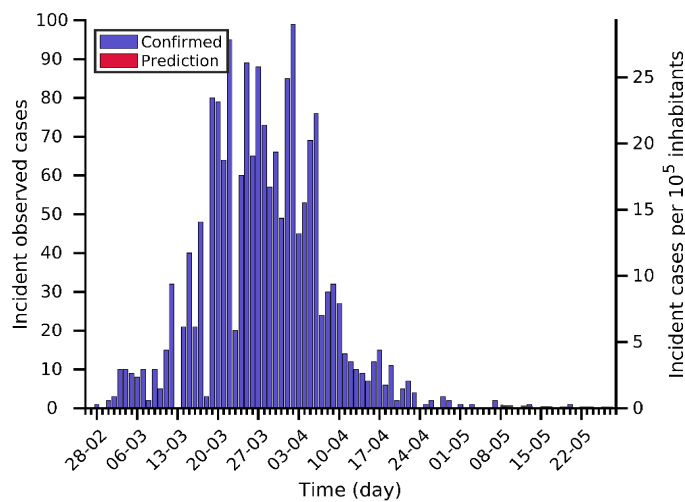
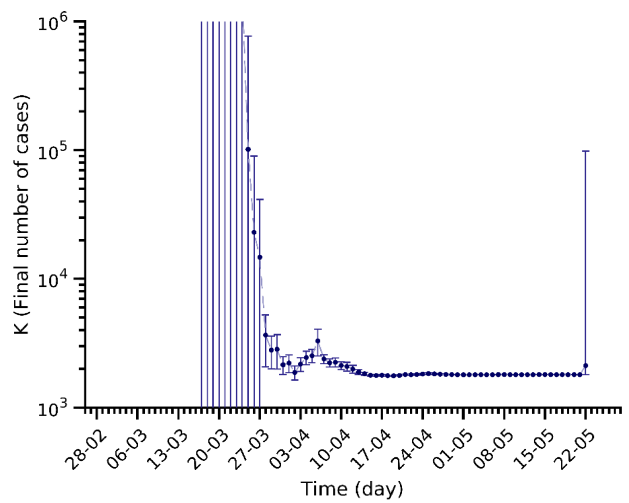
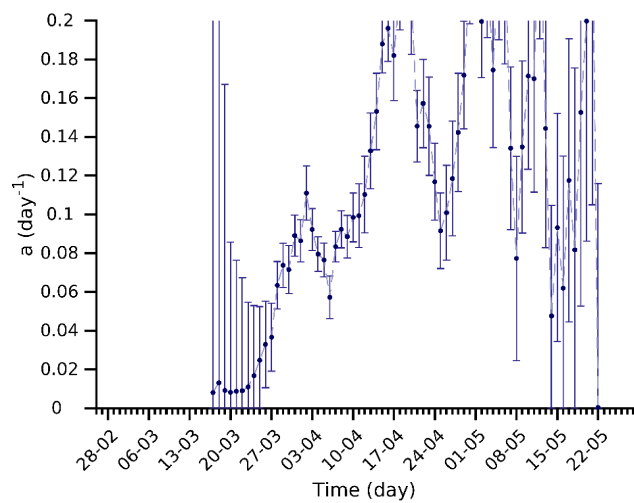
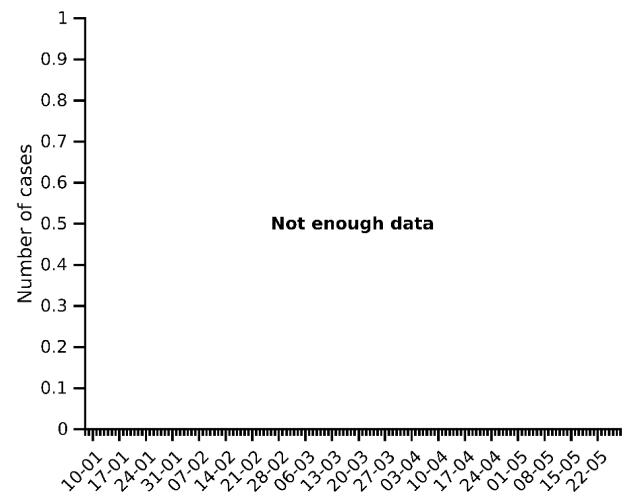
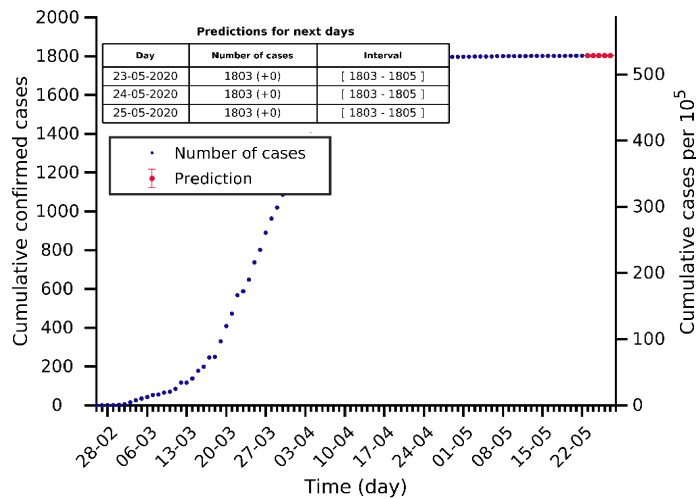
Croatia 22-05-2020. Population: 4.1M. Current cumulated incidence: 55/10⁵



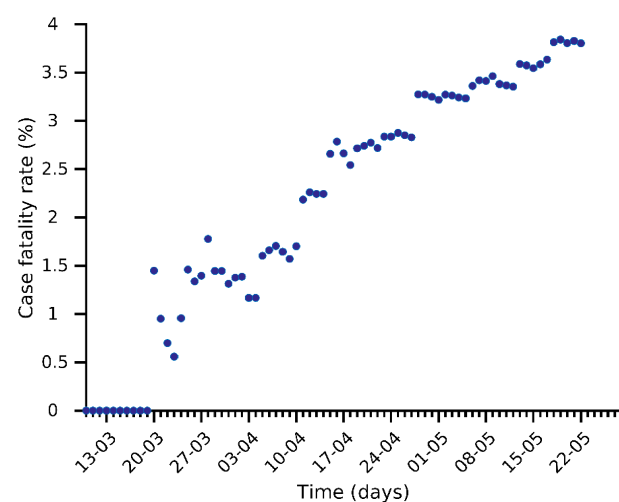
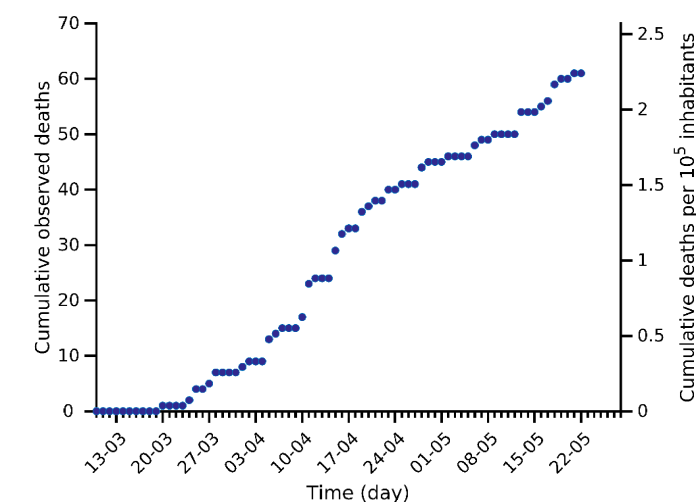
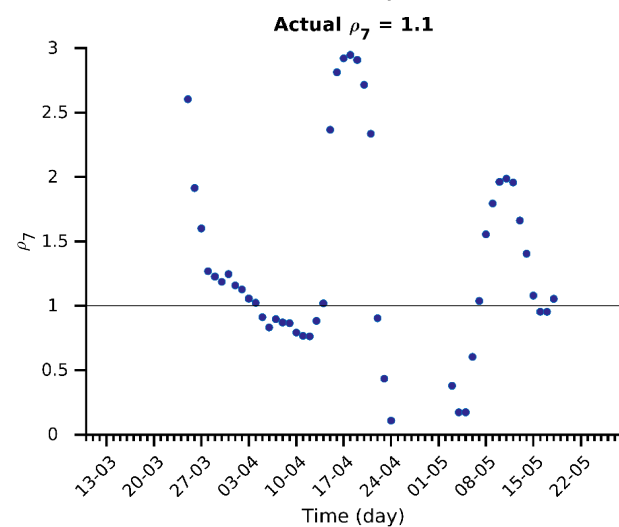
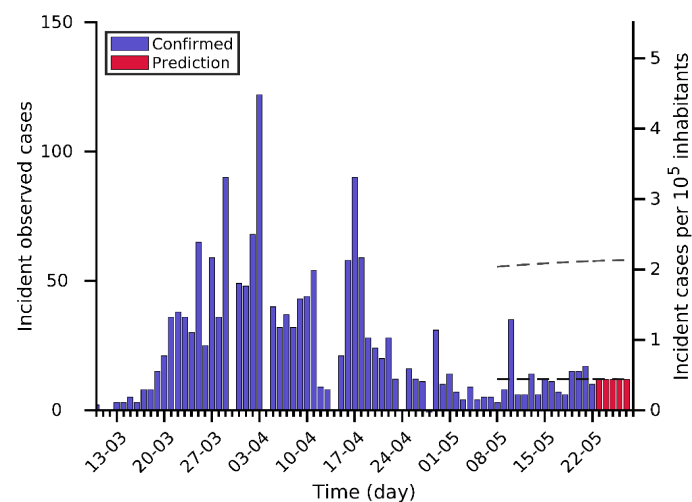
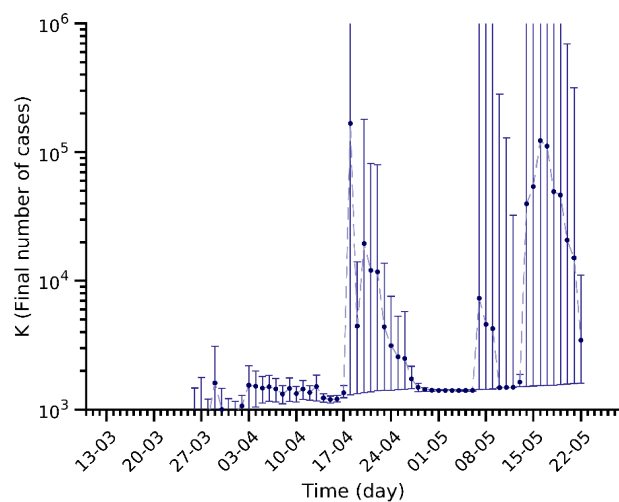
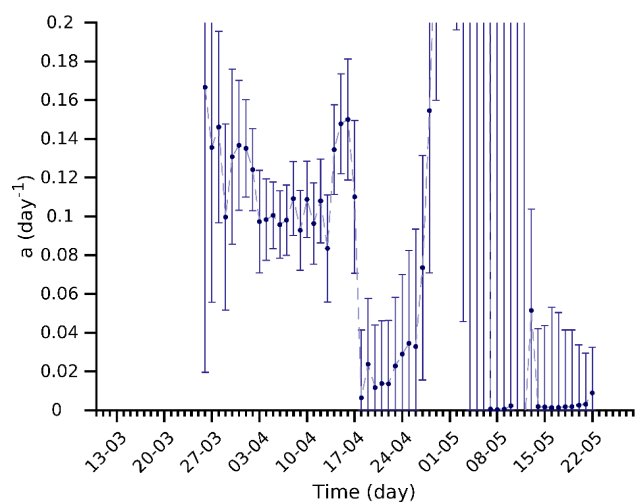
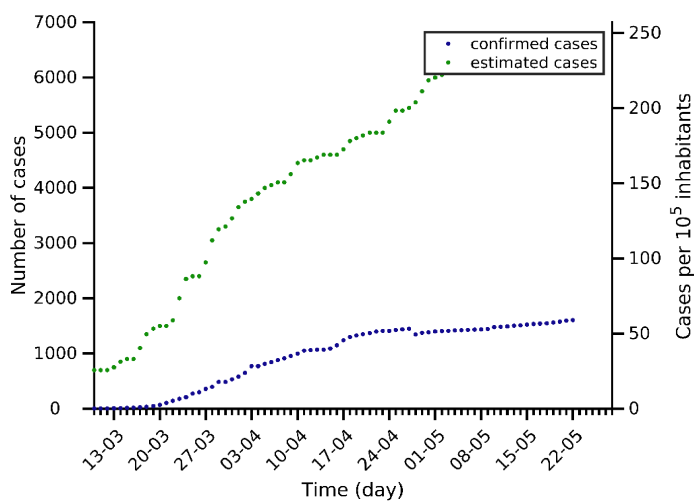
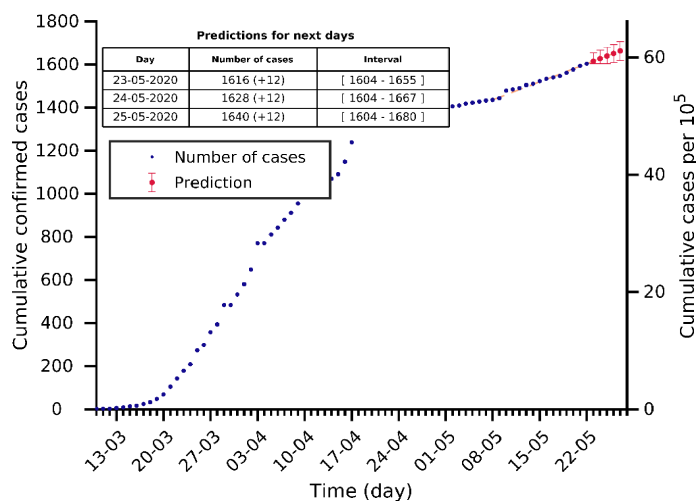
Estonia 22-05-2020. Population: 1.3M. Current cumulated incidence: 136/10⁵



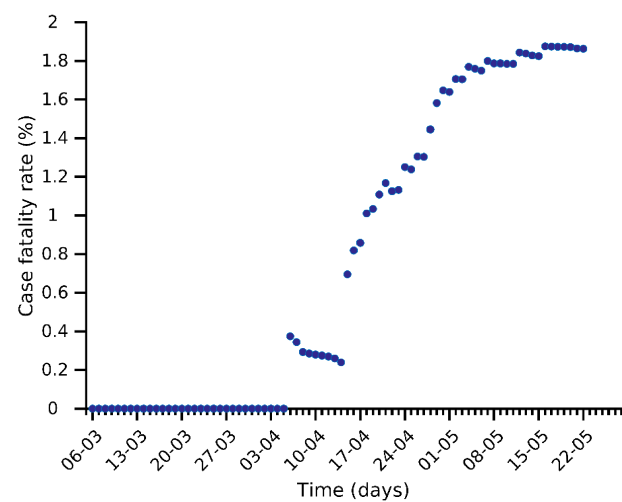
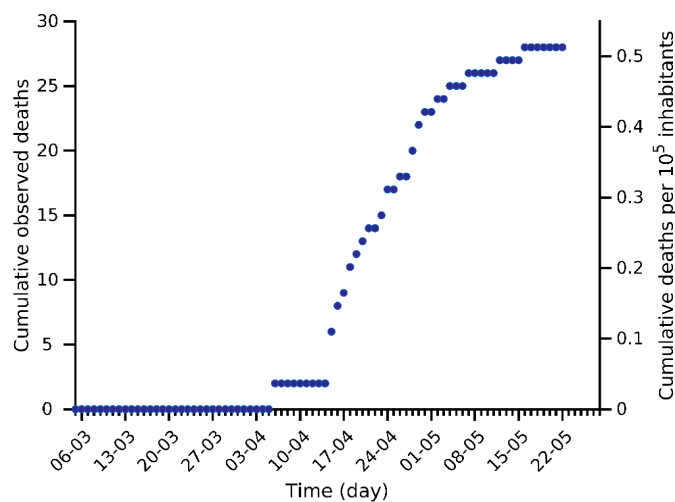
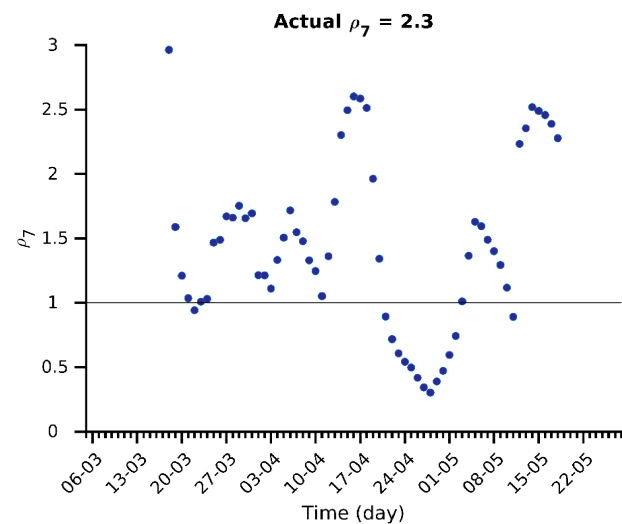
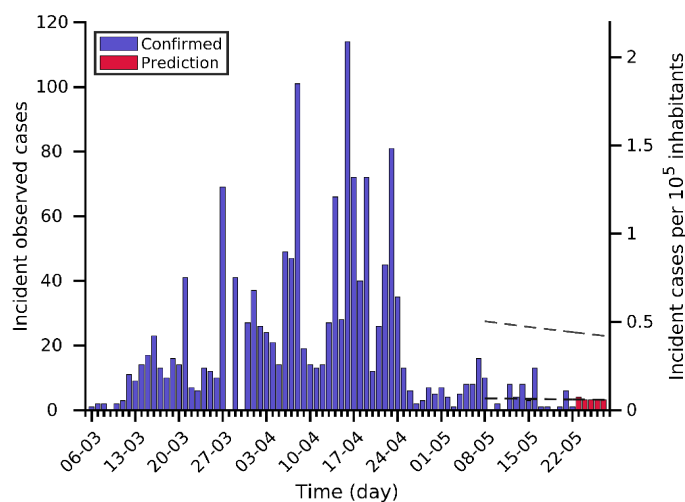
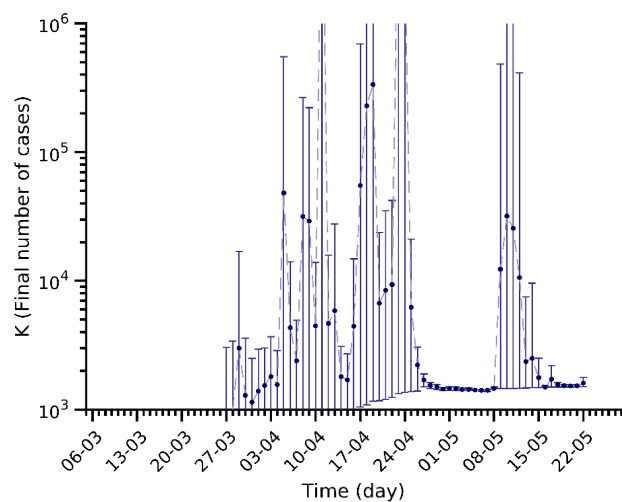
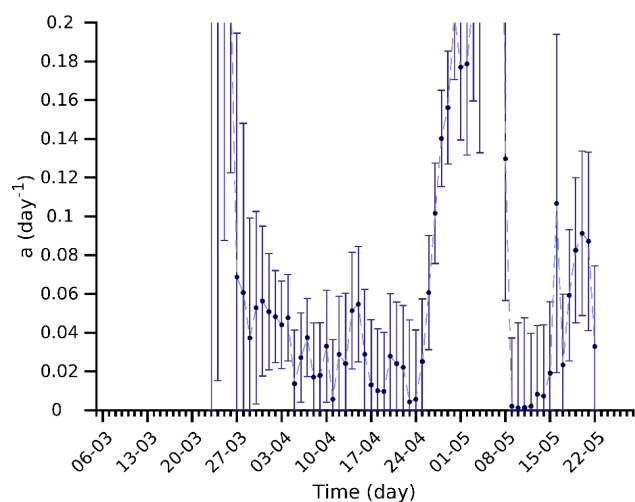
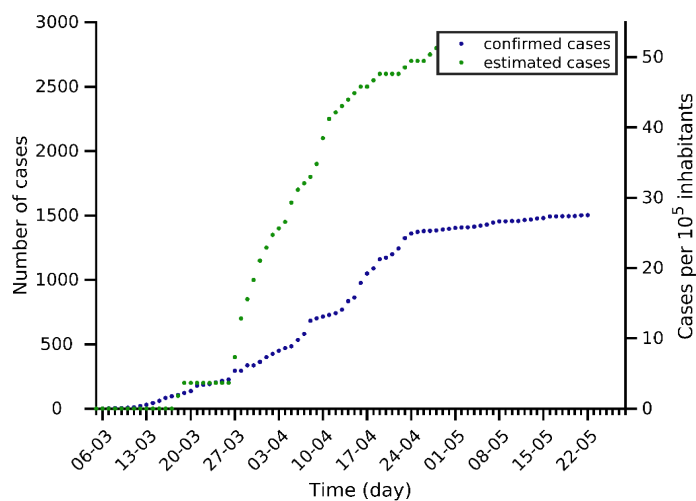
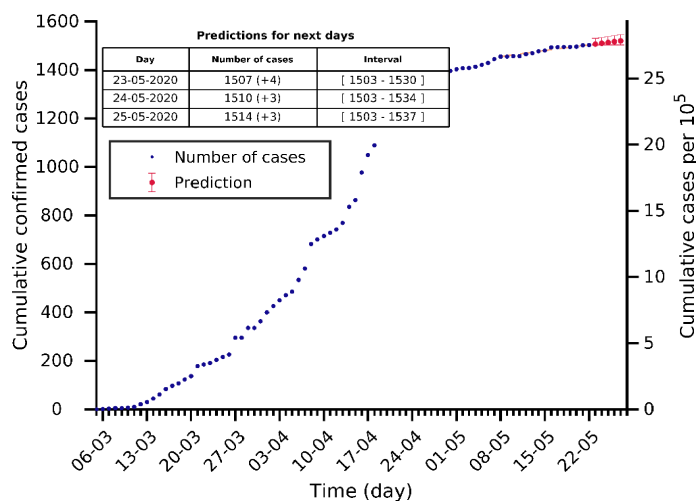
Iceland 22-05-2020. Population: 0.3M. Current cumulated incidence: 528/10⁵



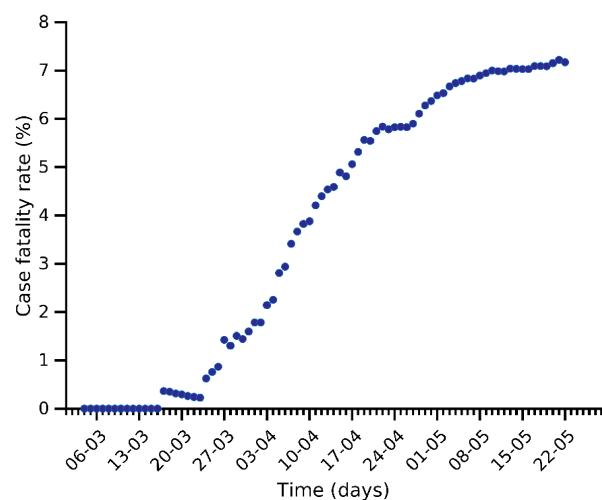
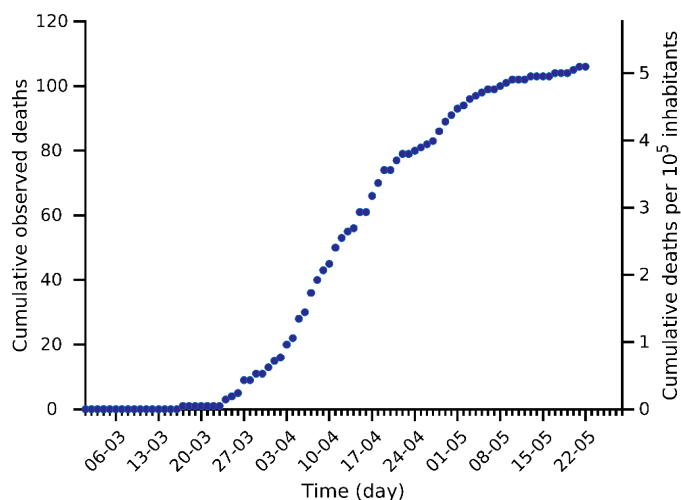
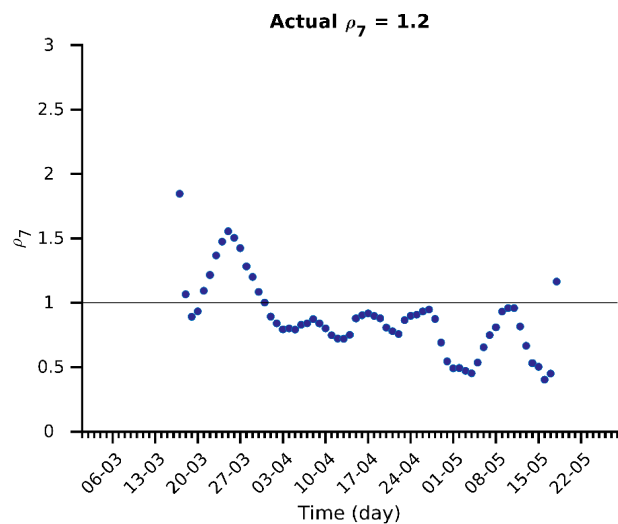
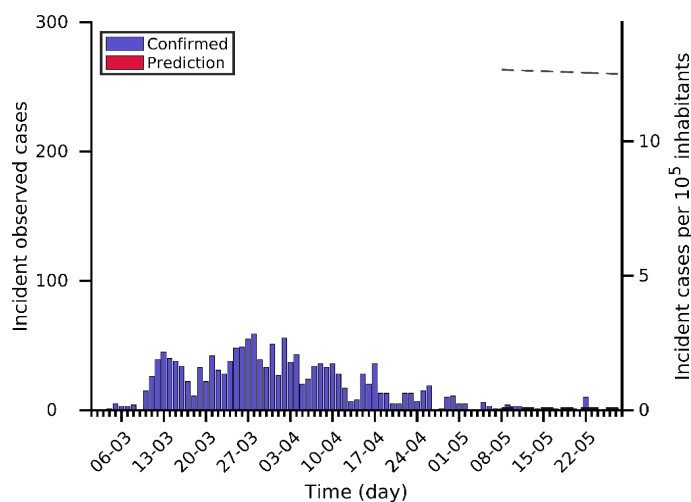
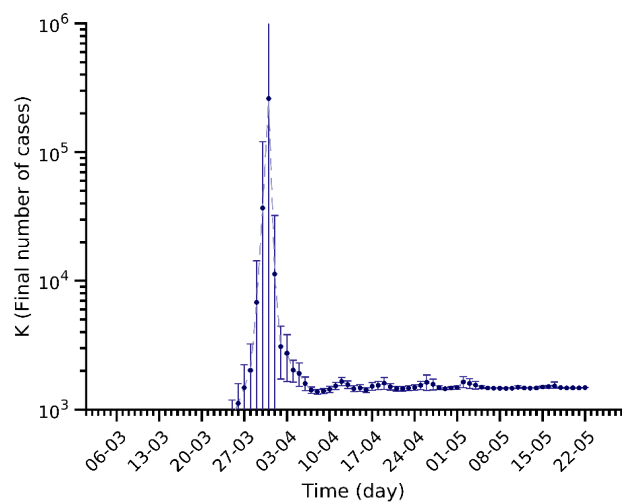
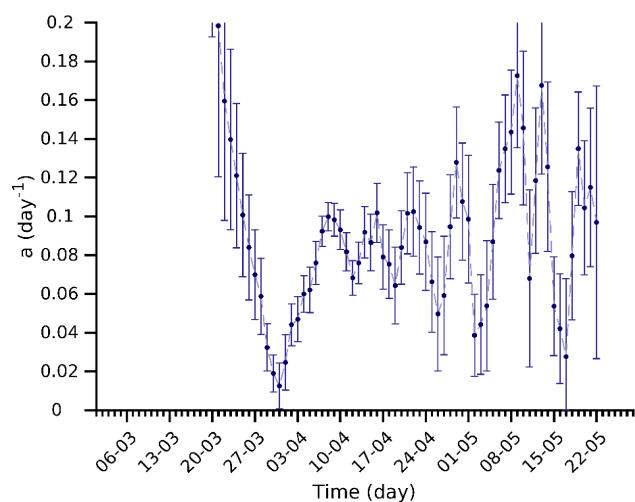
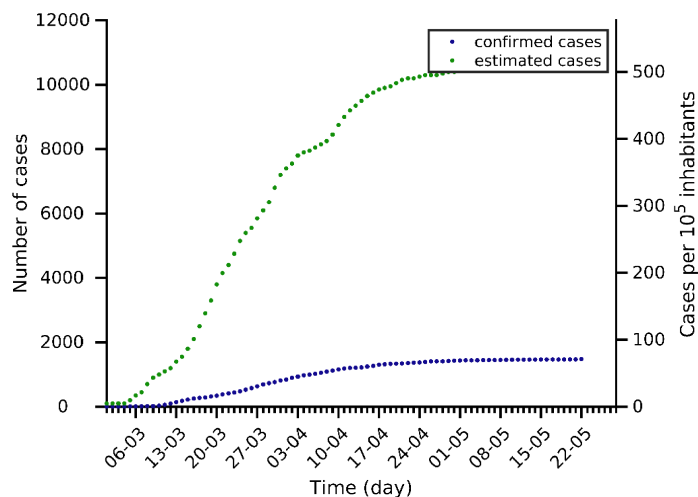
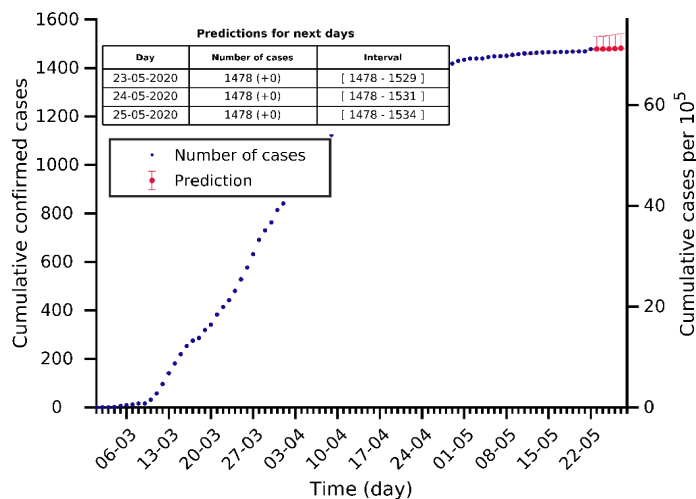
Lithuania 22-05-2020. Population: 2.7M. Current cumulated incidence: 59/10⁵



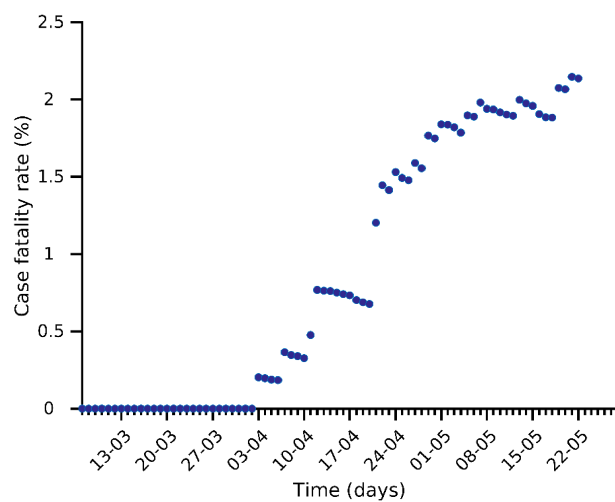
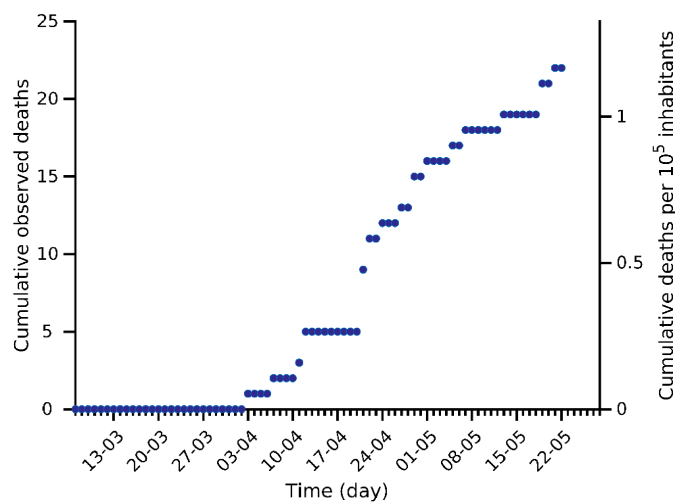
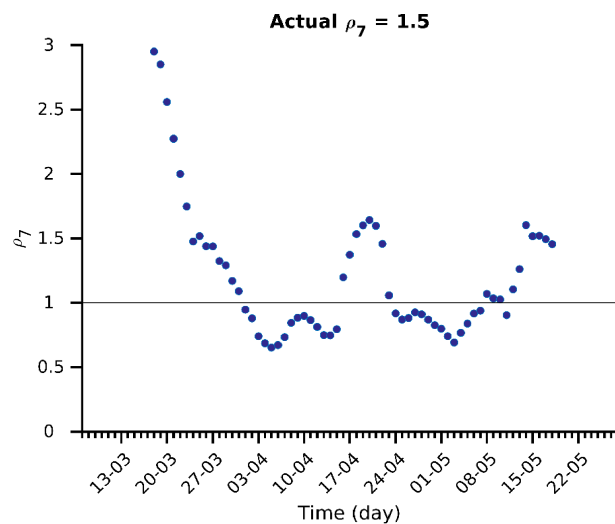
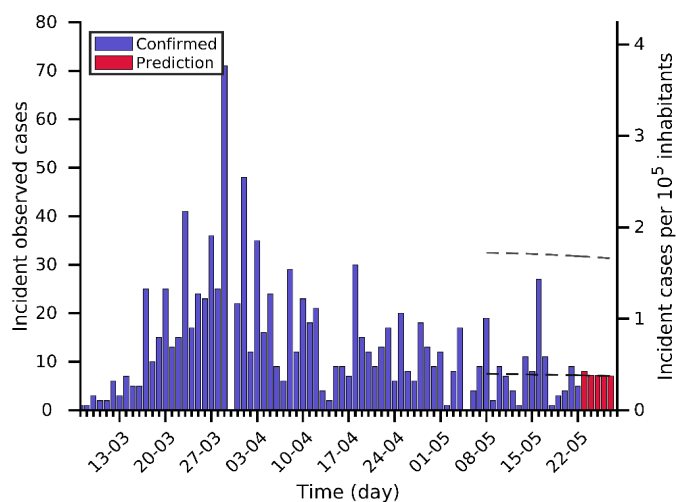
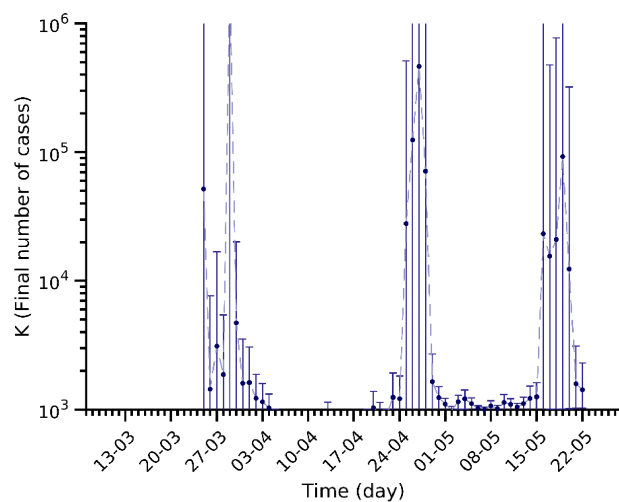
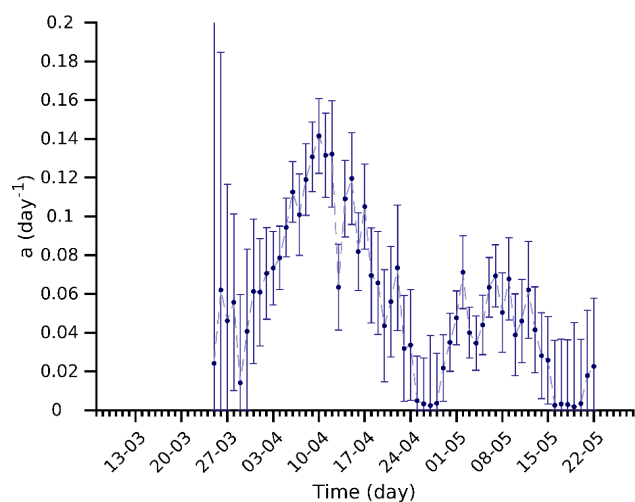
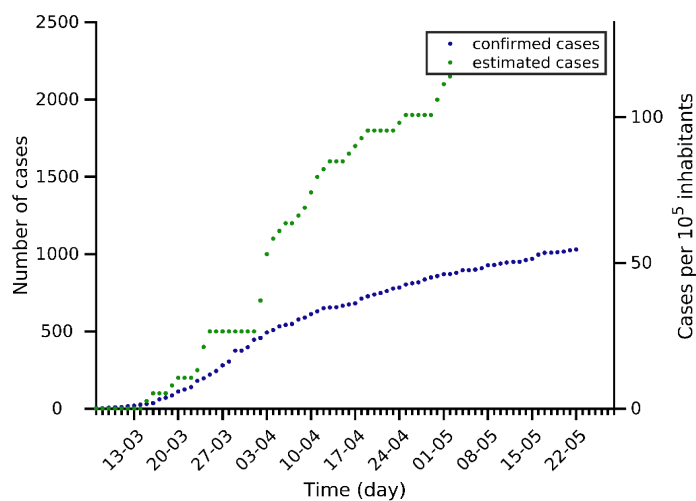
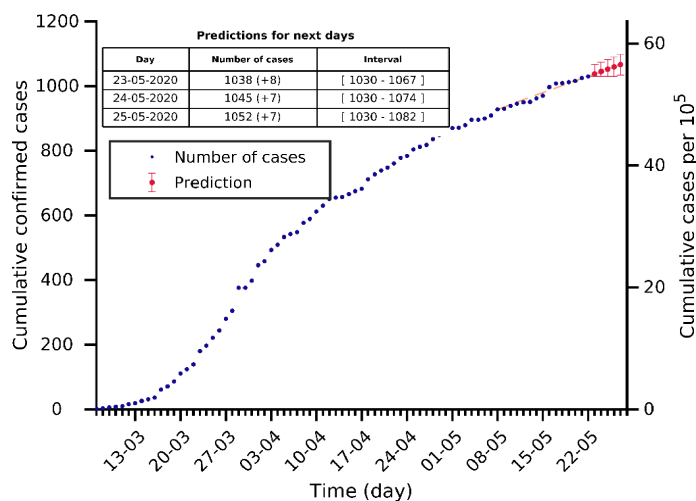
Slovakia 22-05-2020. Population: 5.5M. Current cumulated incidence: $28/10^5$



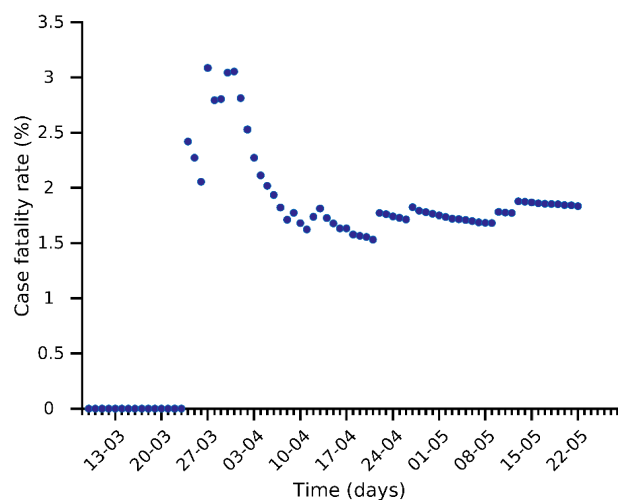
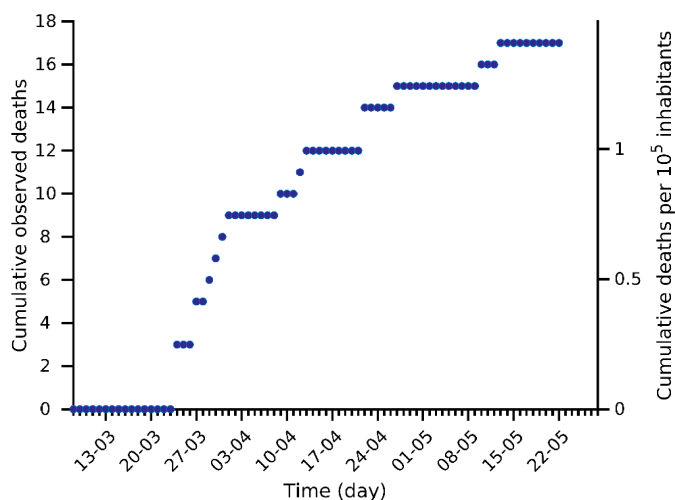
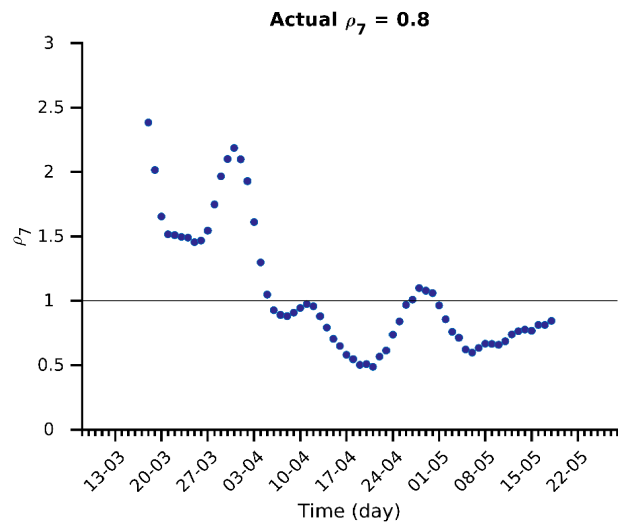
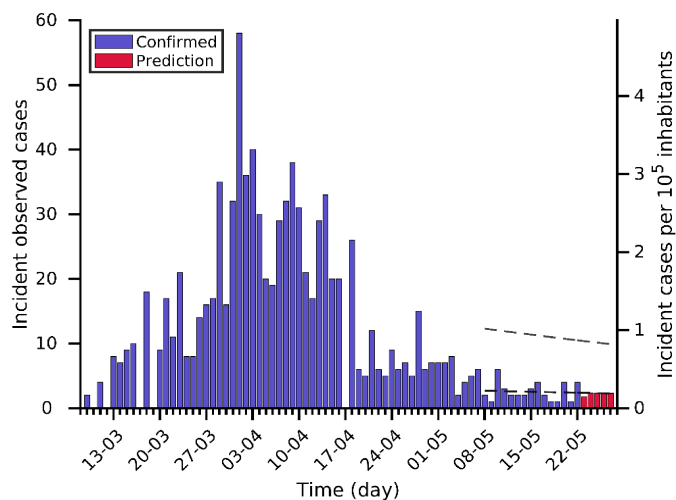
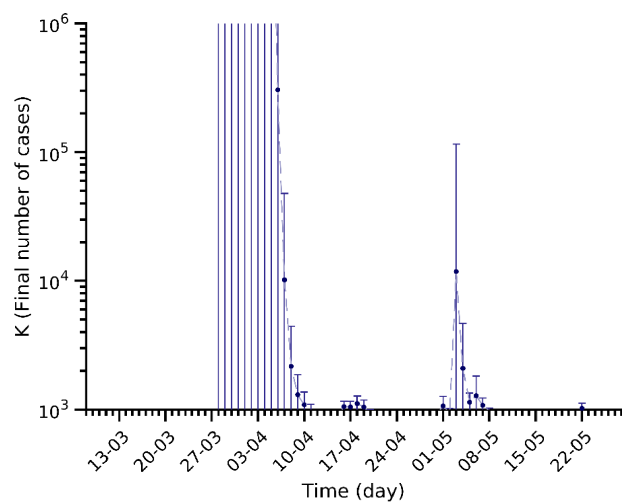
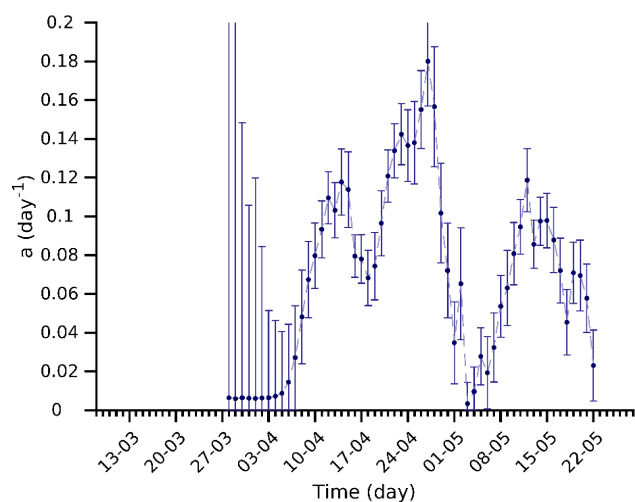
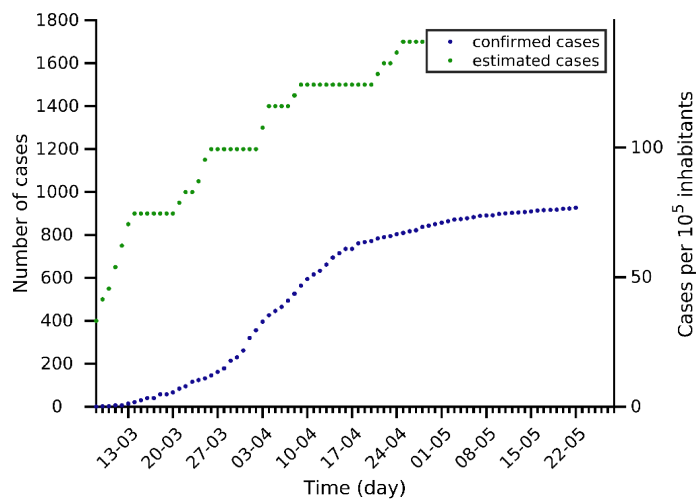
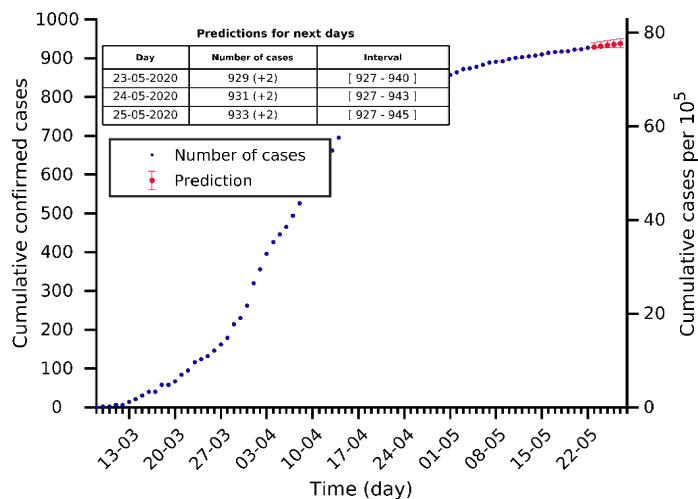
Slovenia 22-05-2020. Population: 2.1M. Current cumulated incidence: 71/10⁵



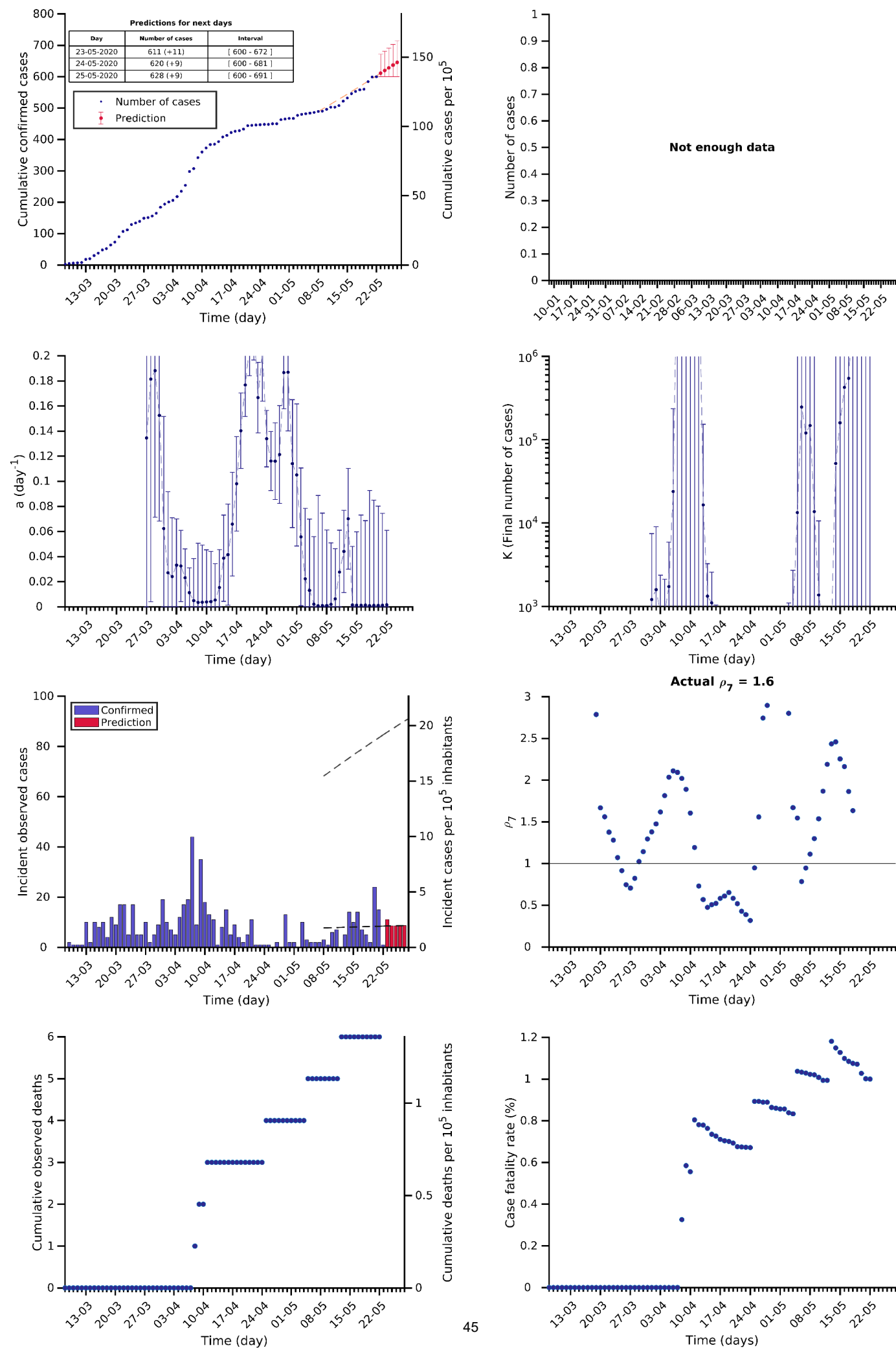
Latvia 22-05-2020. Population: 1.9M. Current cumulated incidence: 55/10⁵



Cyprus 22-05-2020. Population: 1.2M. Current cumulated incidence: 77/10⁵



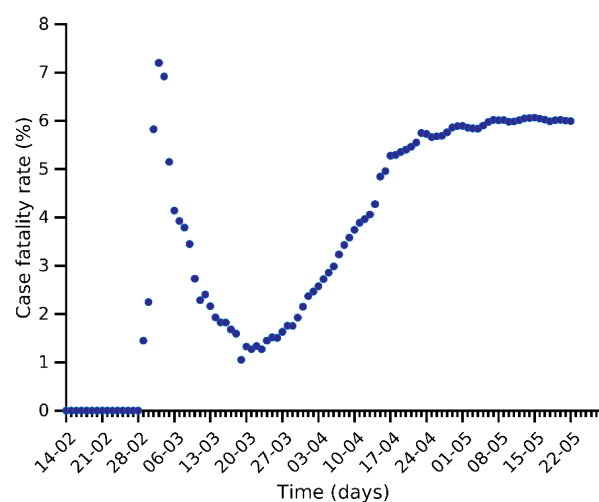
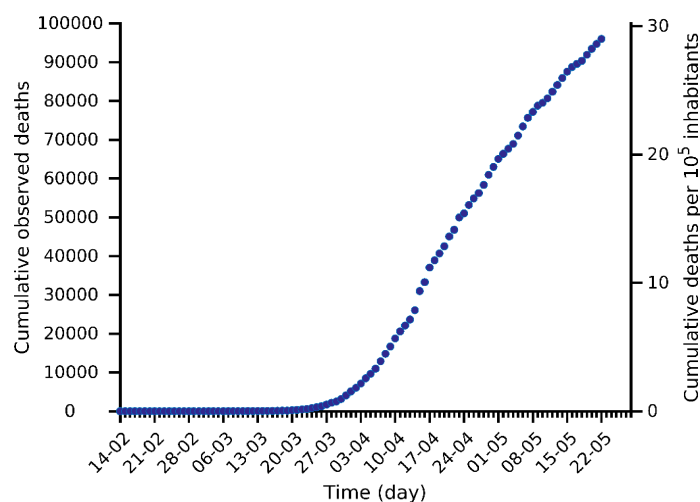
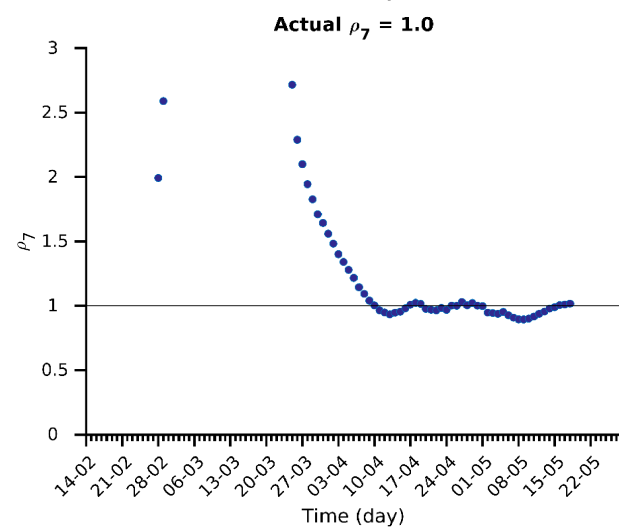
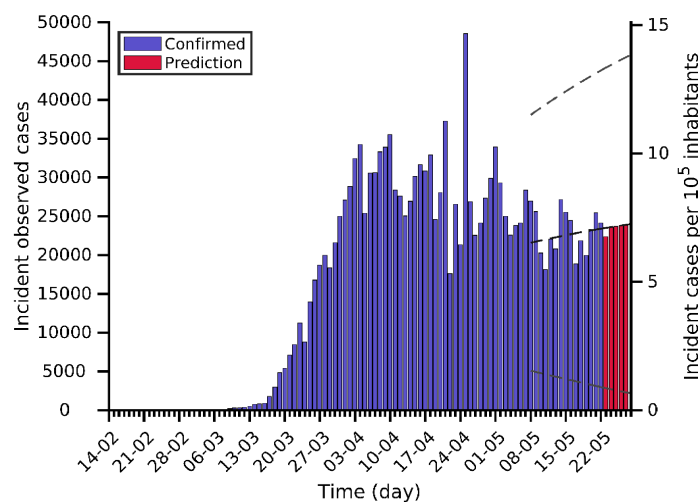
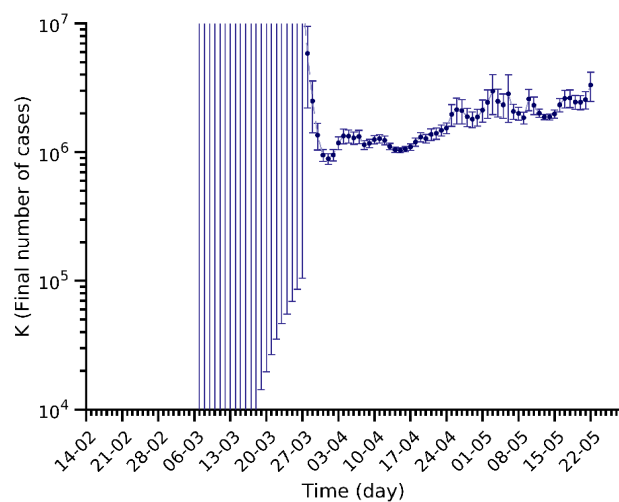
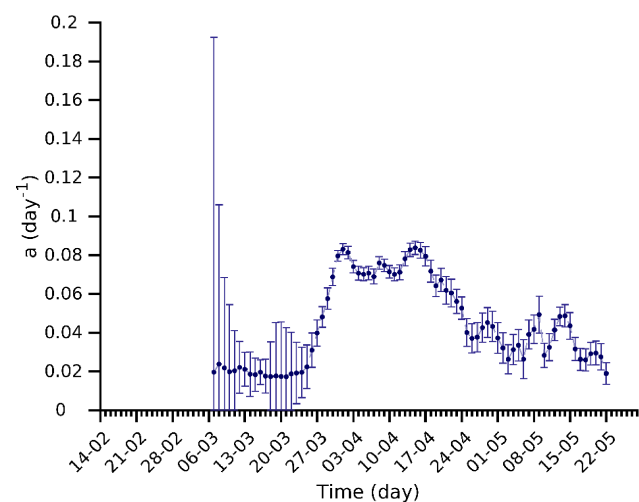
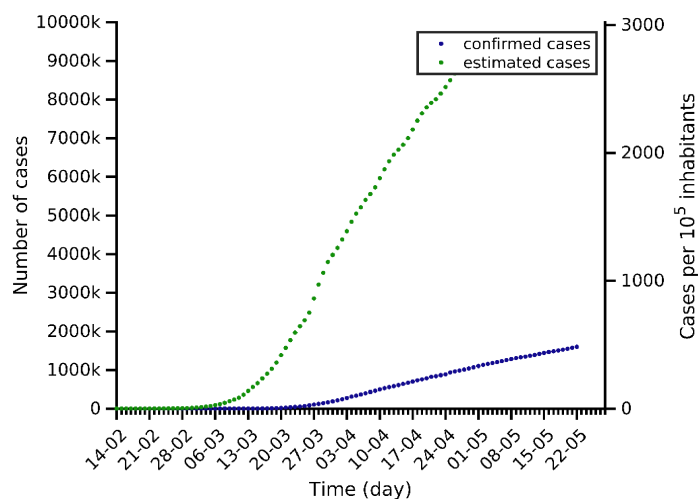
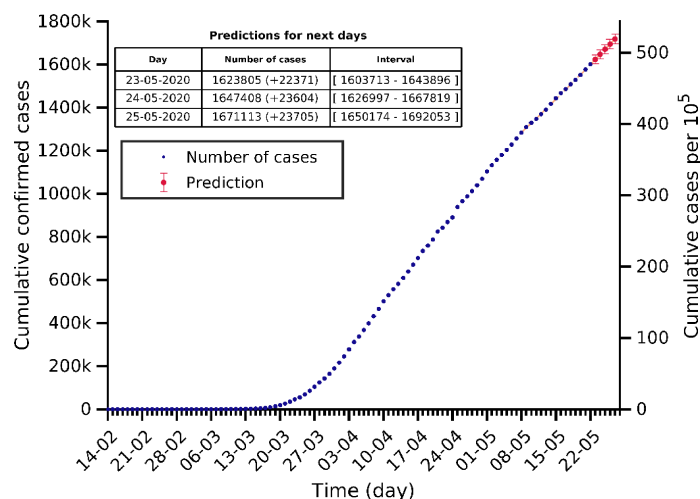
Malta 22-05-2020. Population: 0.4M. Current cumulated incidence: 136/10⁵



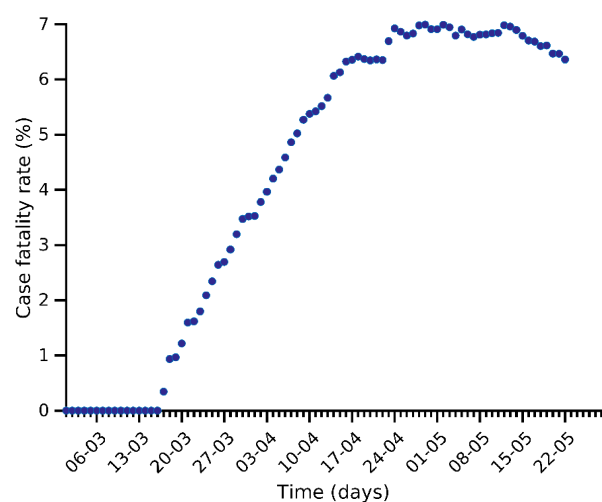
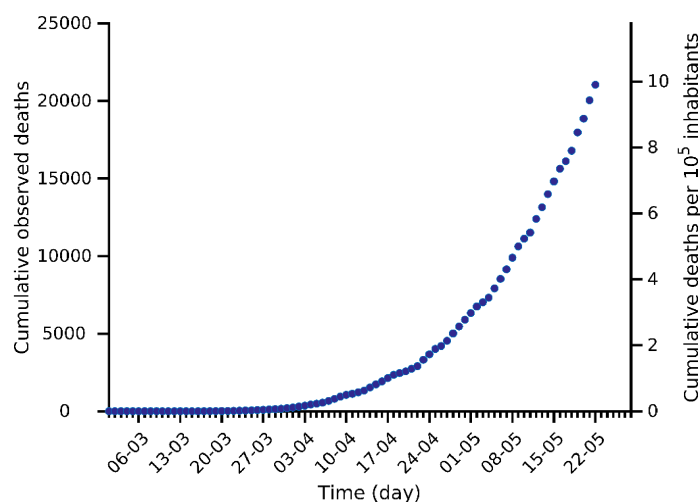
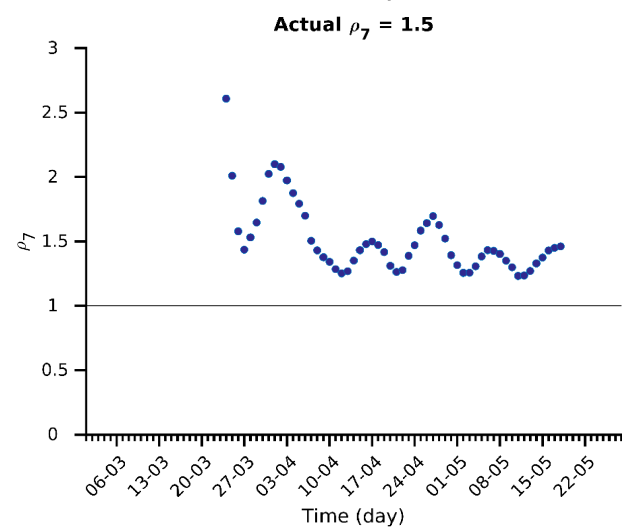
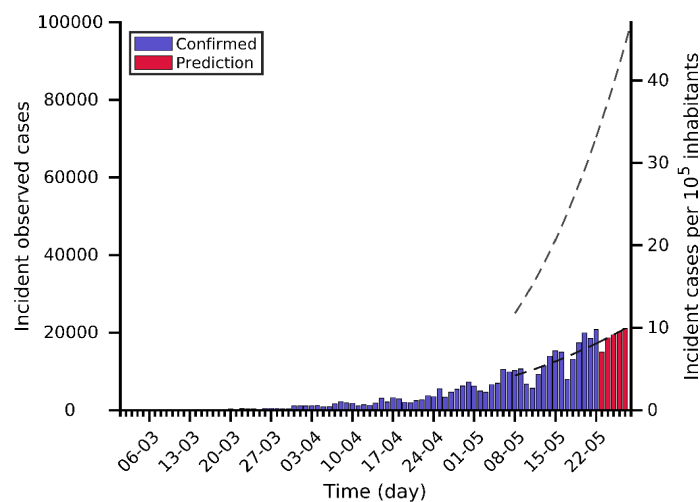
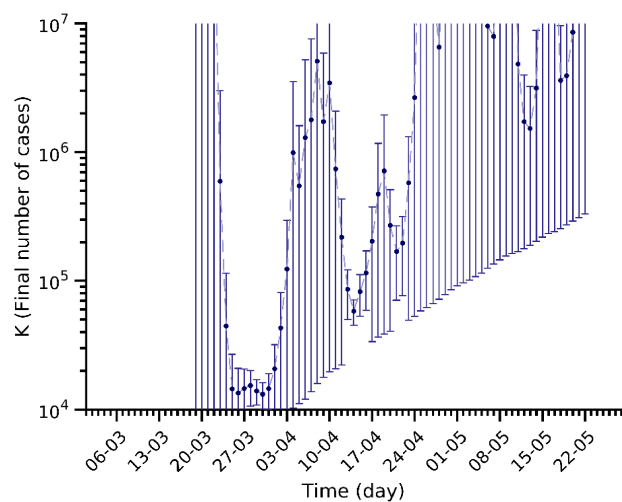
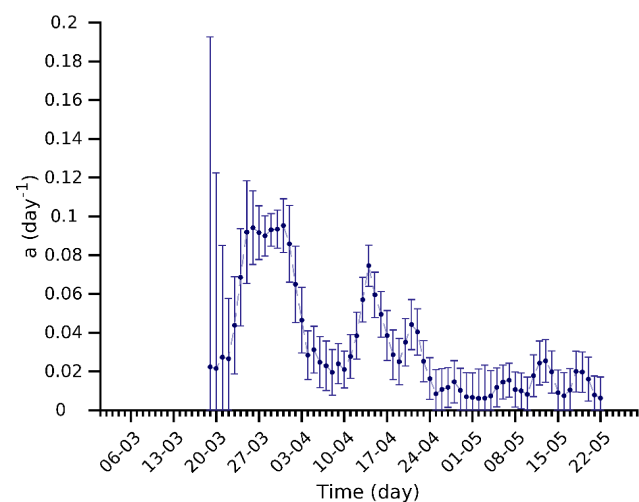
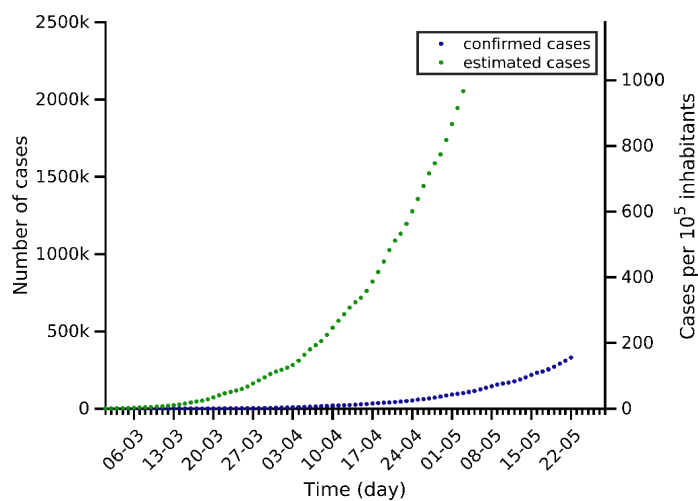
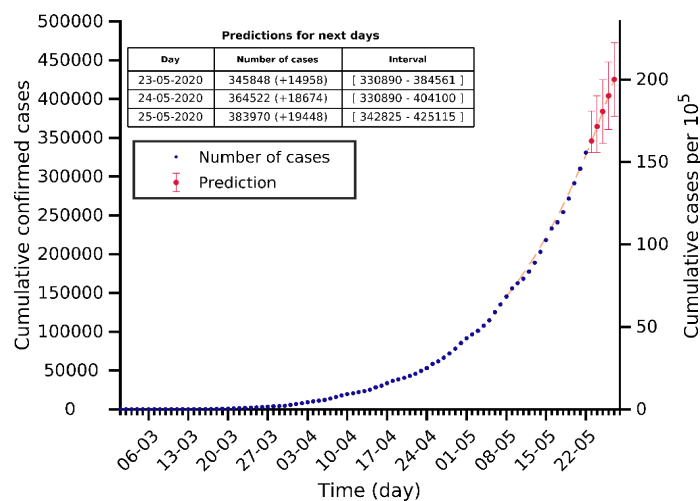
(2) Analysis and prediction of COVID-19 for other countries

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

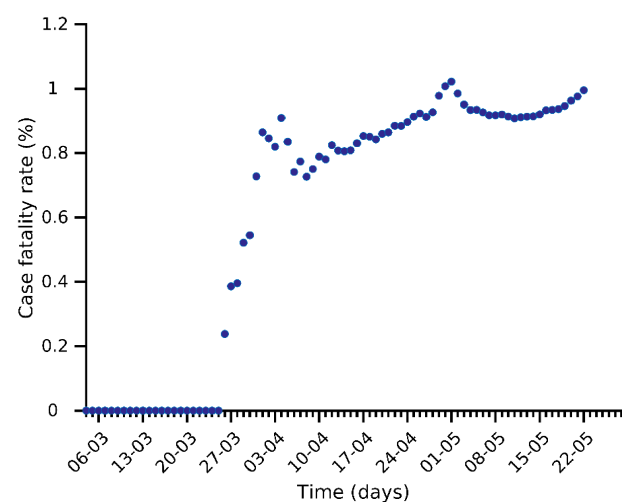
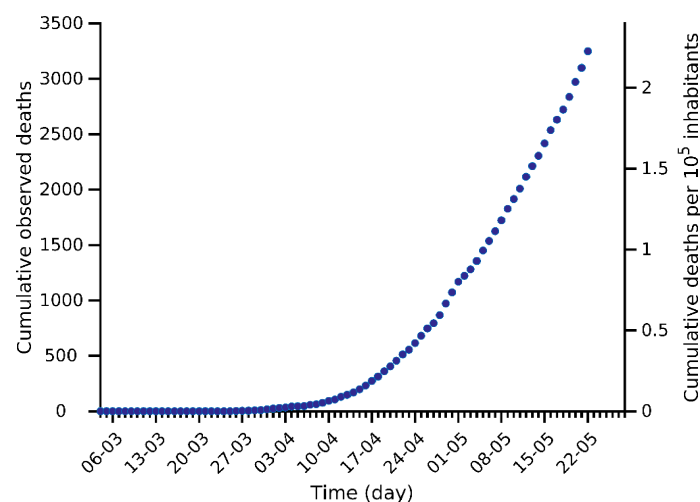
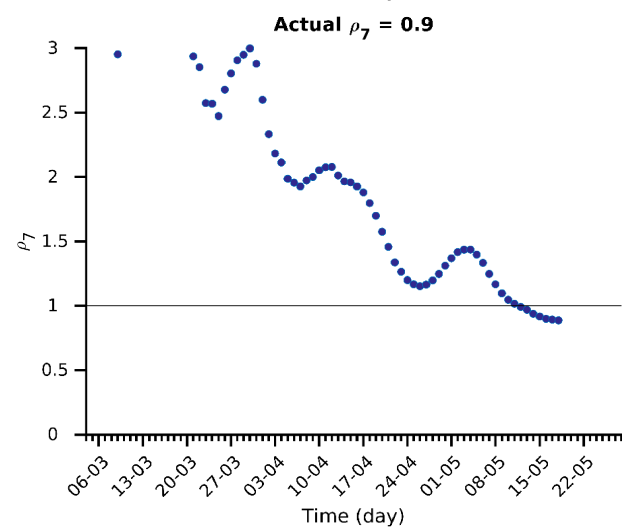
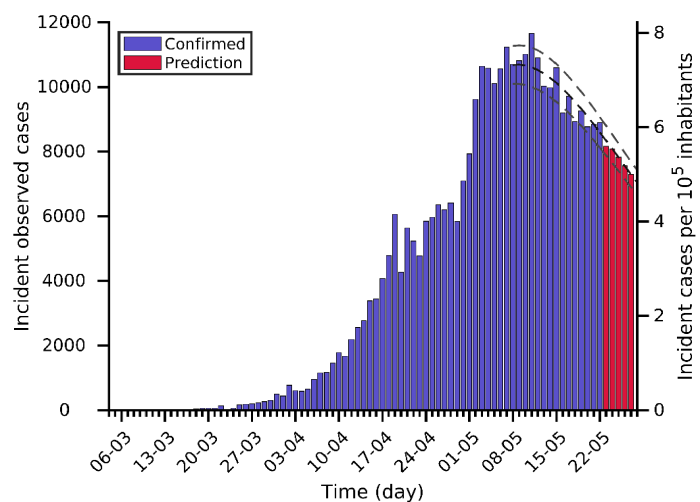
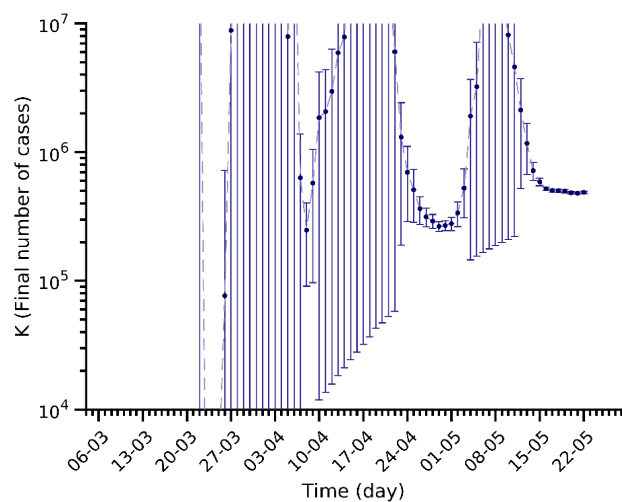
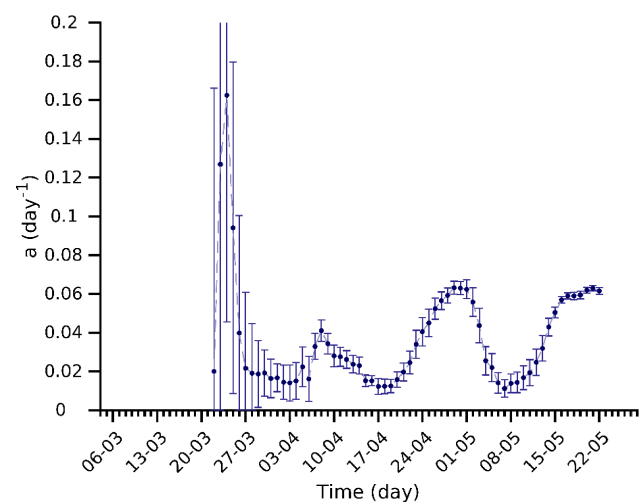
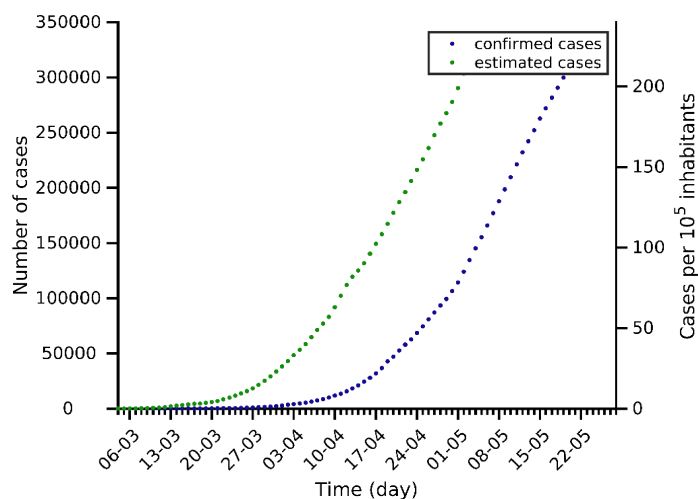
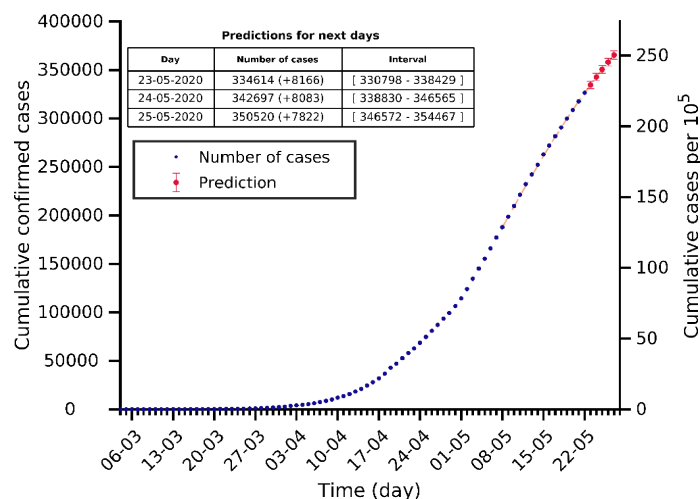
USA 22-05-2020. Population: 331.0M. Current cumulated incidence: 484/10⁵



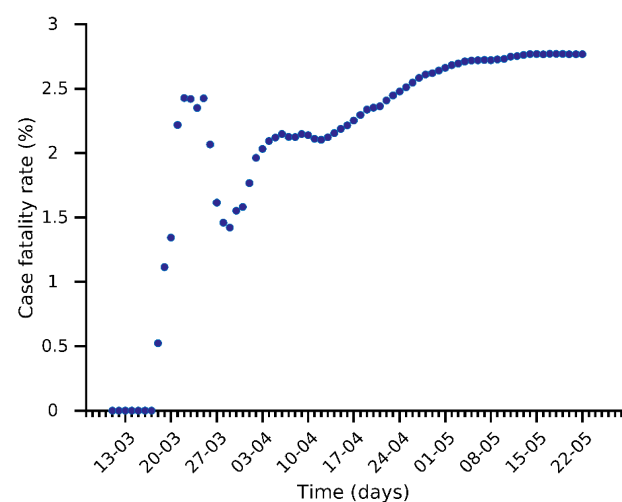
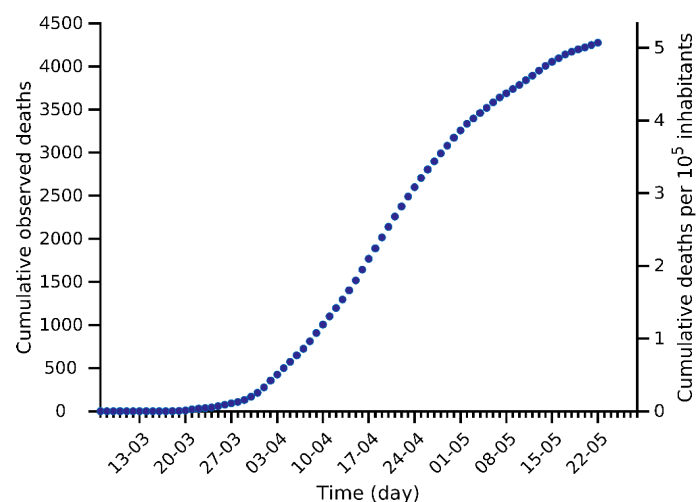
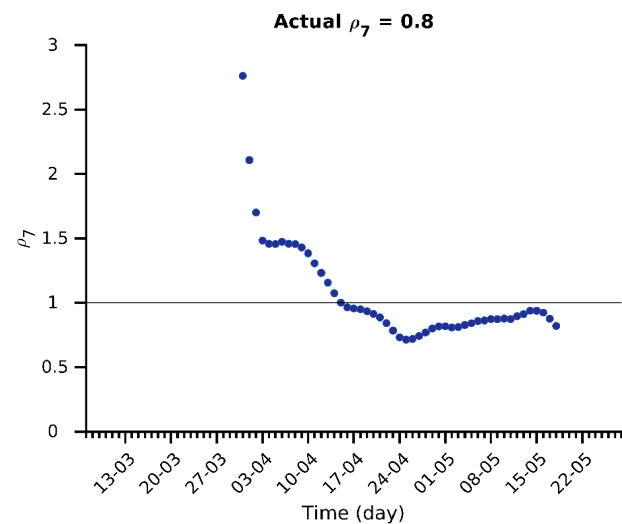
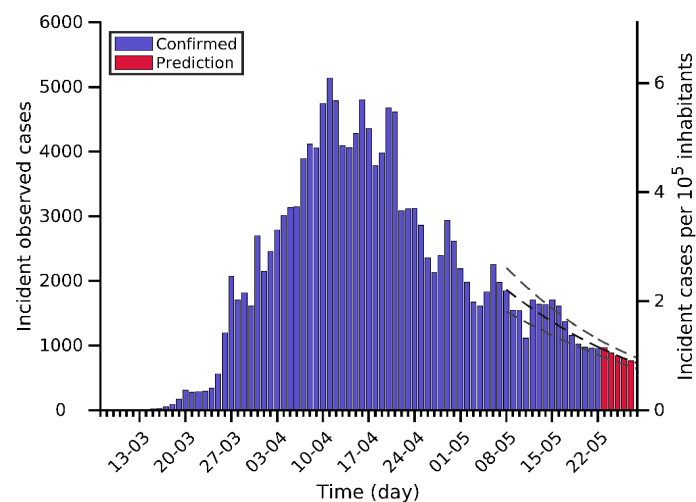
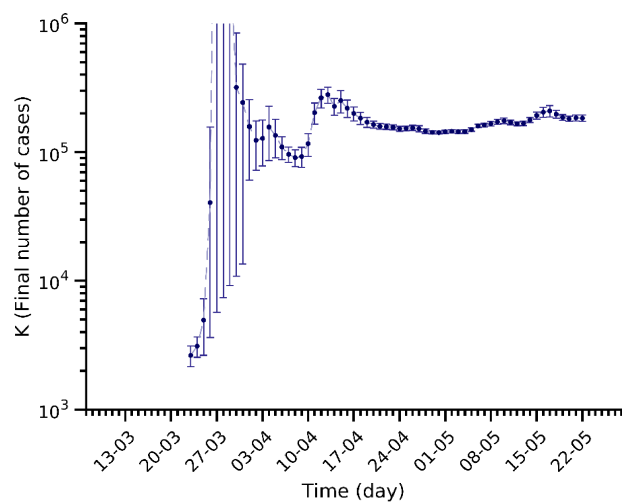
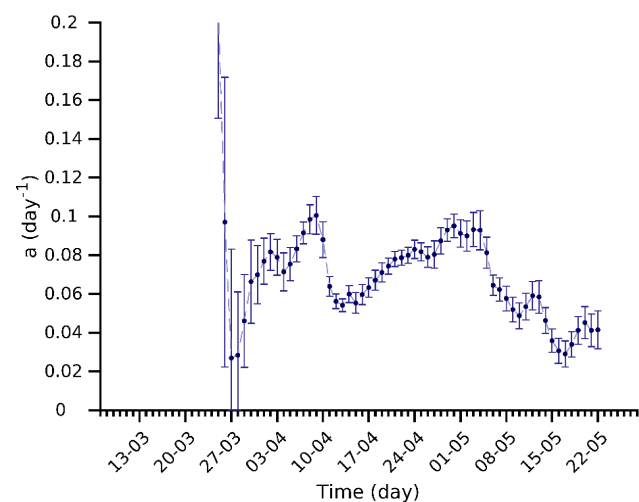
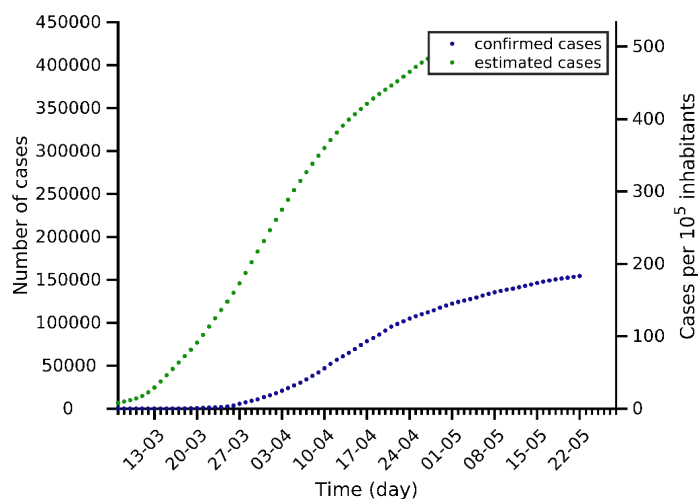
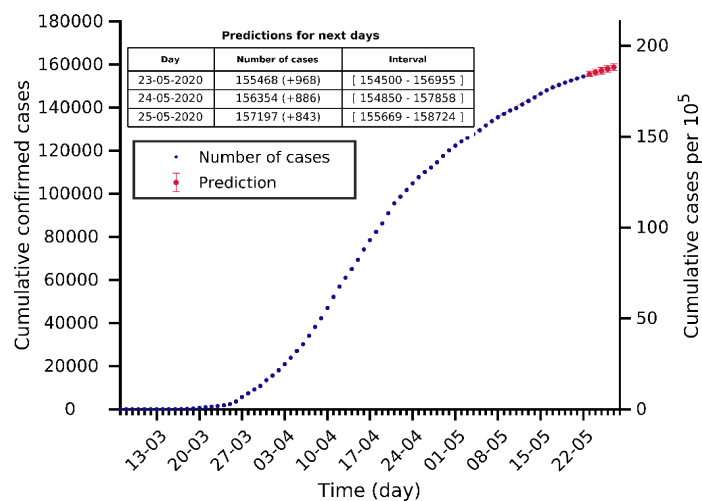
Brazil 22-05-2020. Population: 212.6M. Current cumulated incidence: 156/10⁵



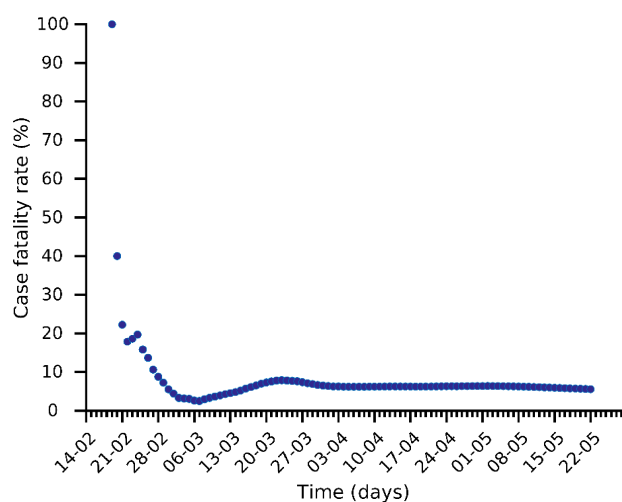
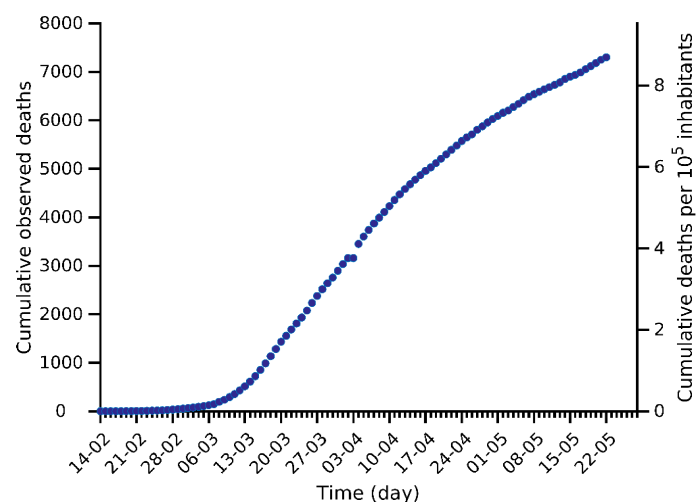
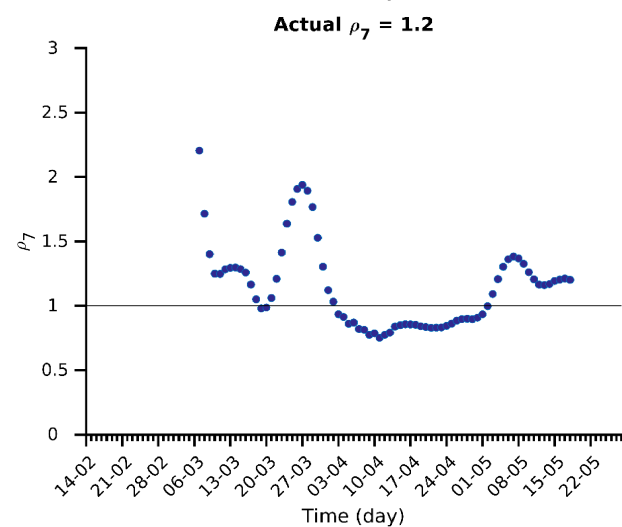
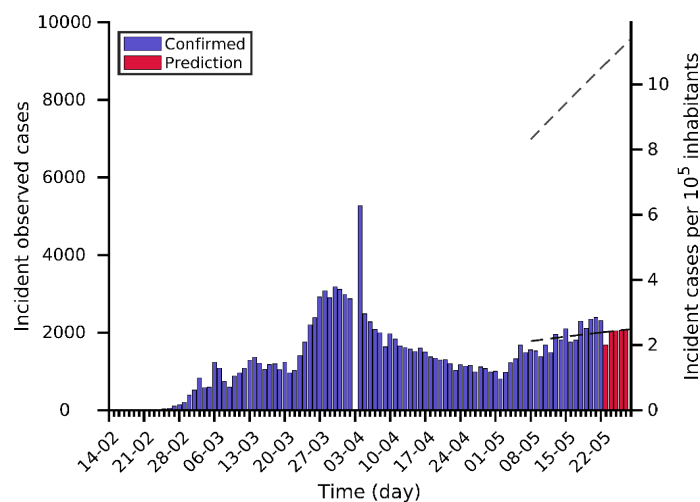
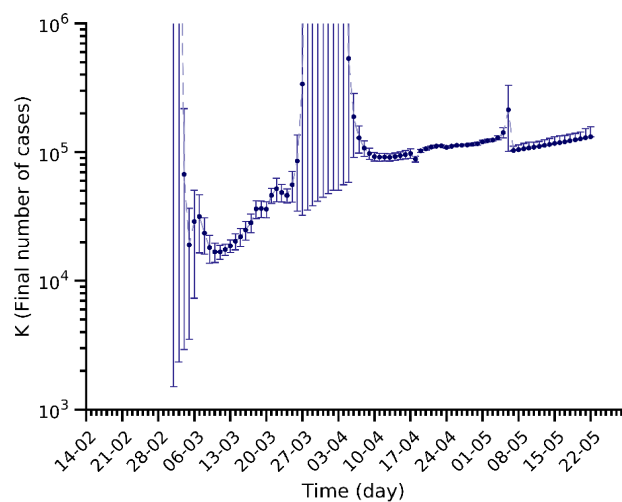
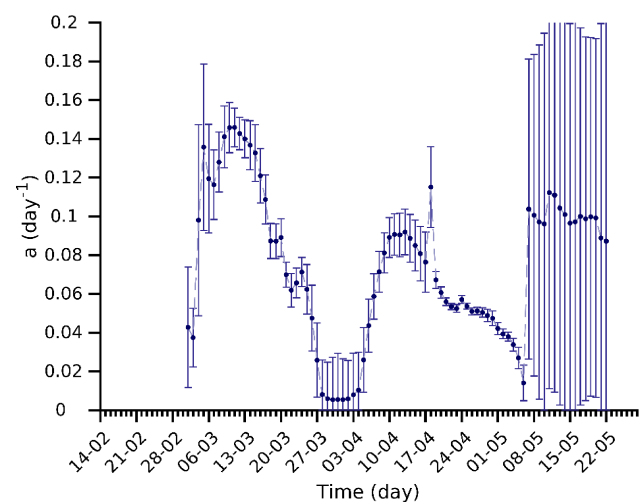
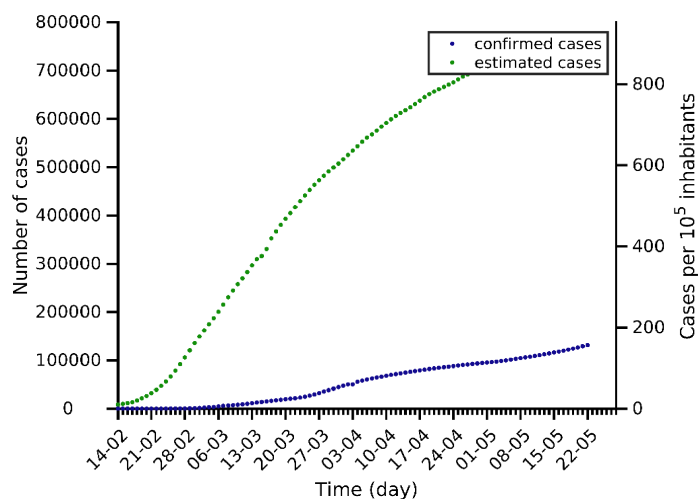
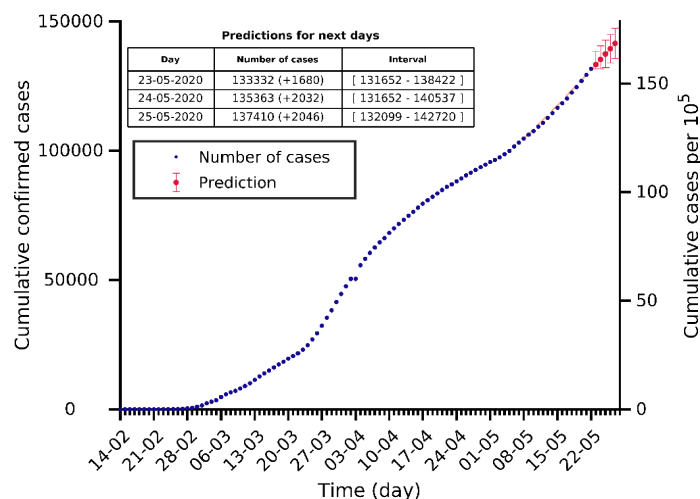
Russia 22-05-2020. Population: 145.9M. Current cumulated incidence: 224/10⁵



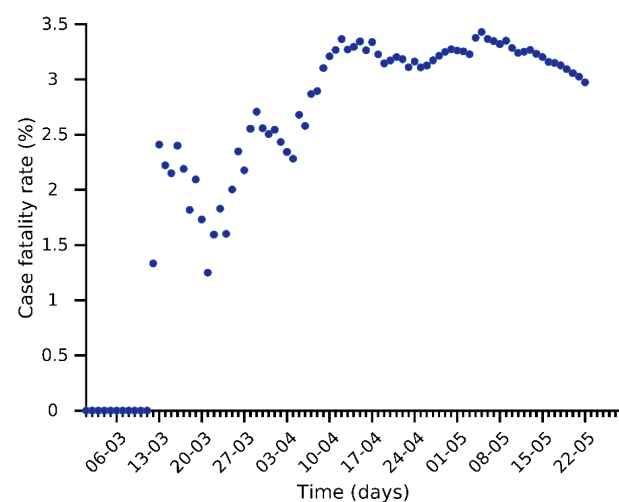
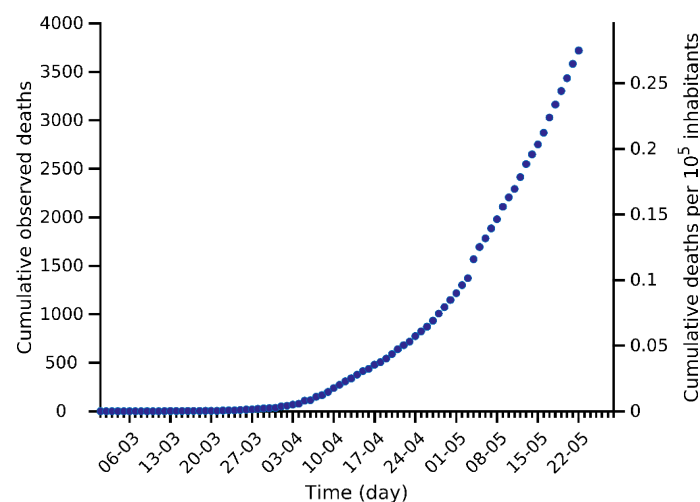
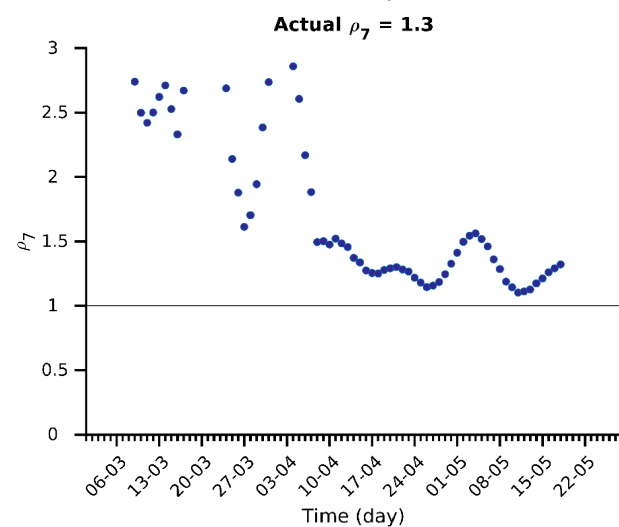
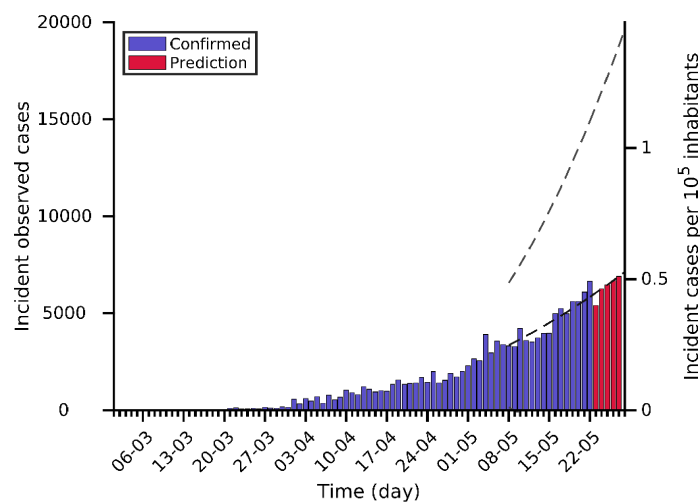
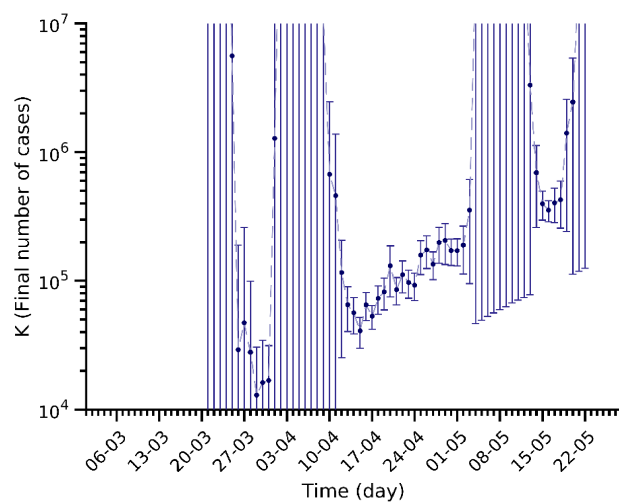
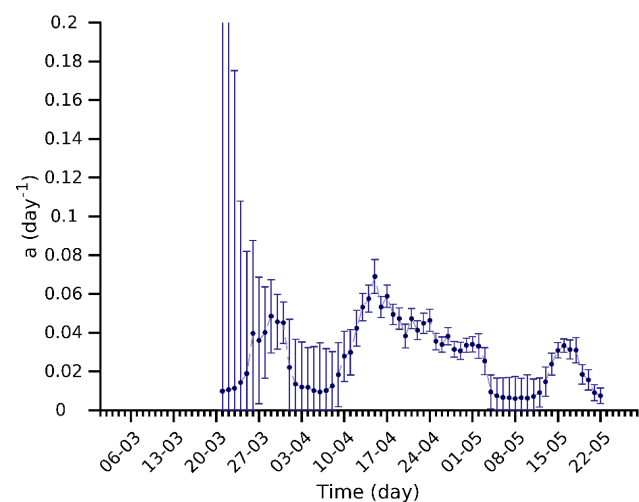
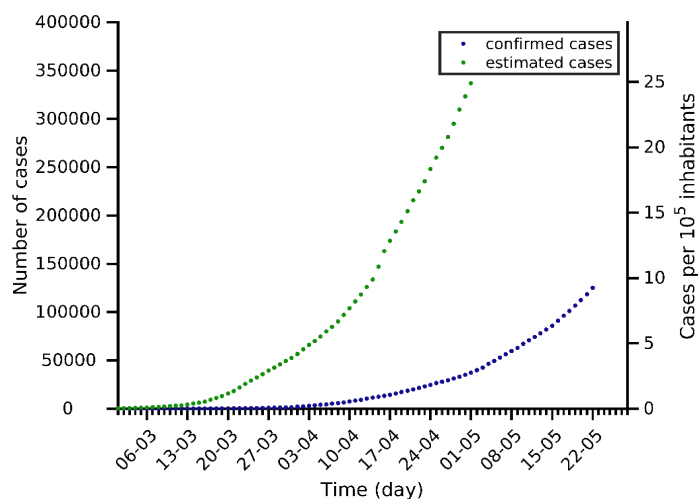
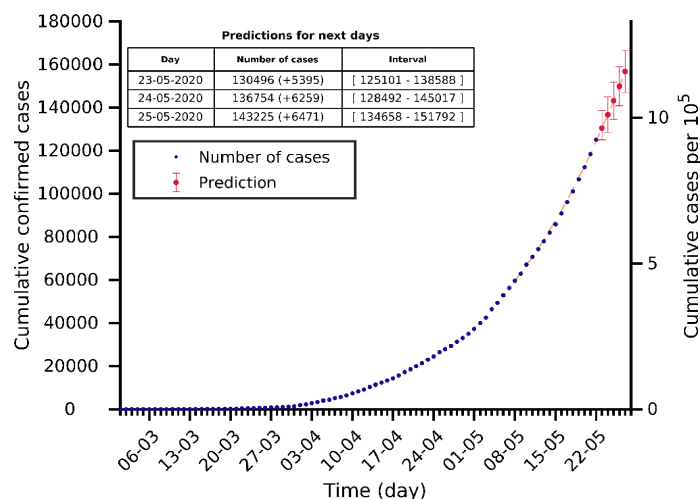
Turkey 22-05-2020. Population: 84.3M. Current cumulated incidence: 183/10⁵



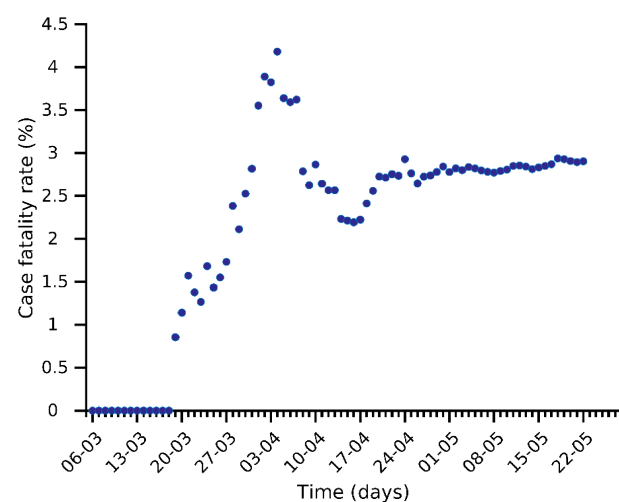
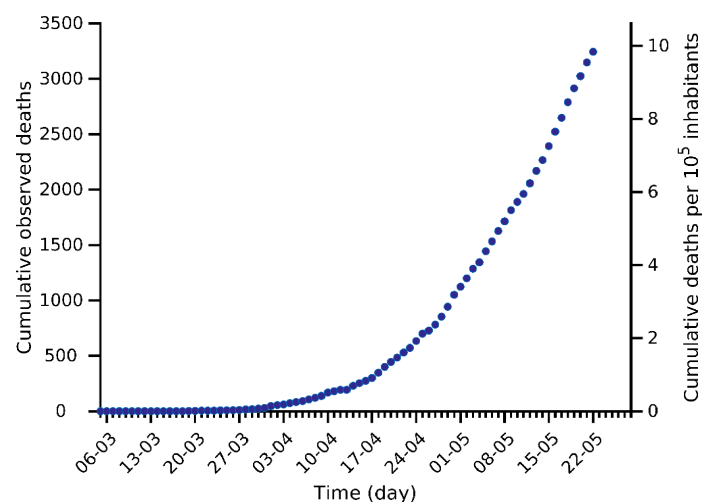
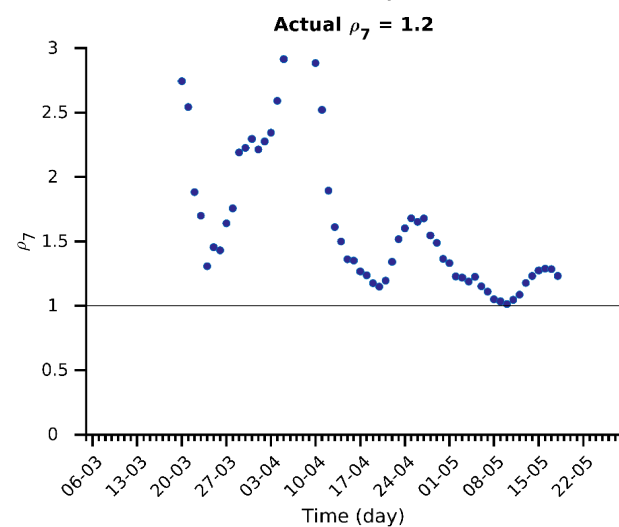
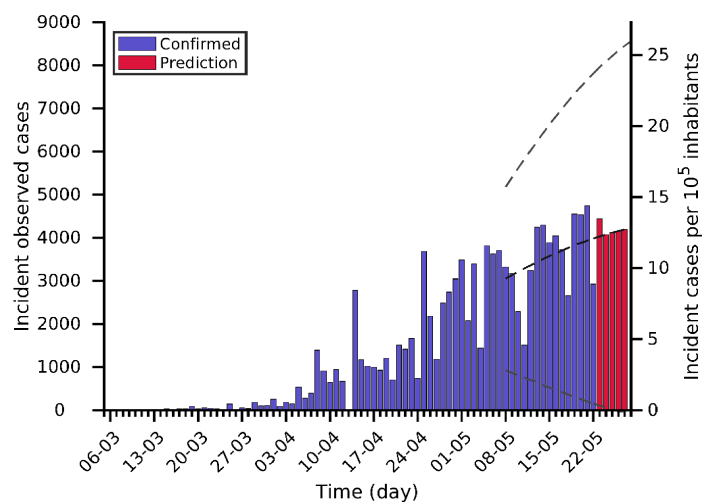
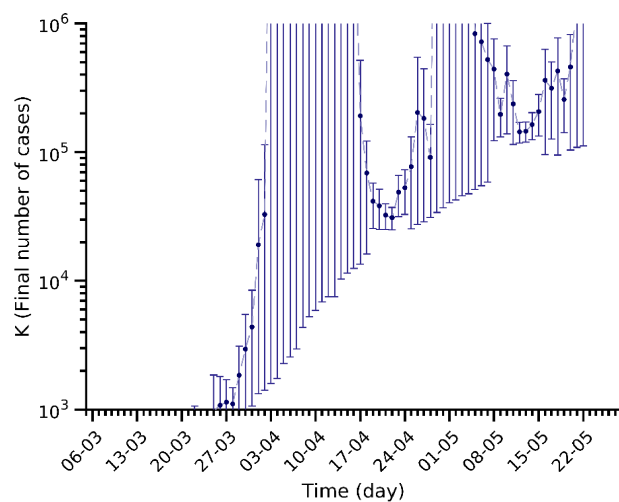
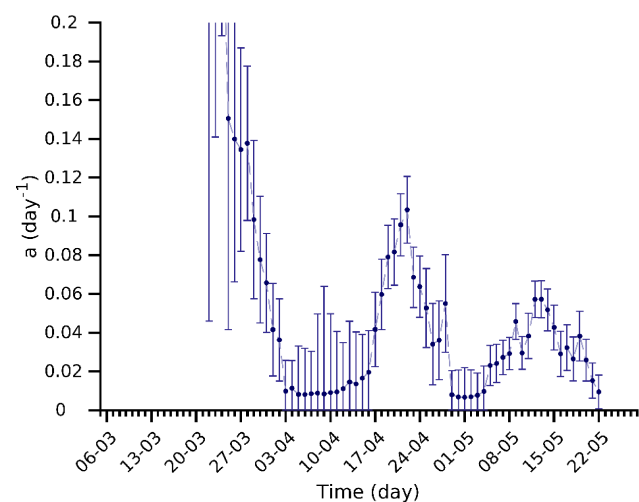
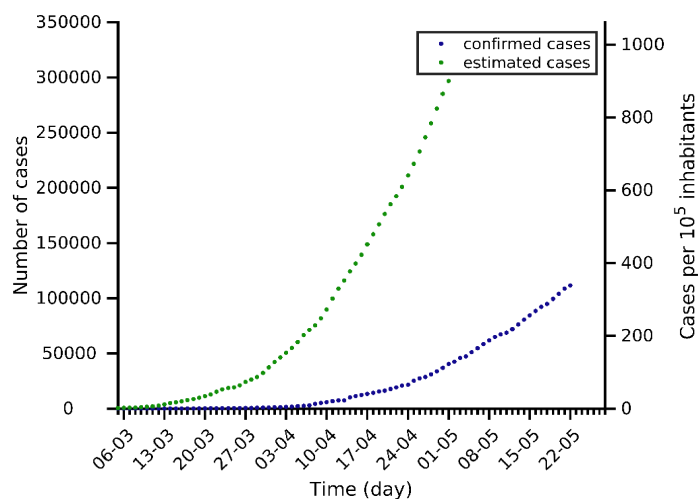
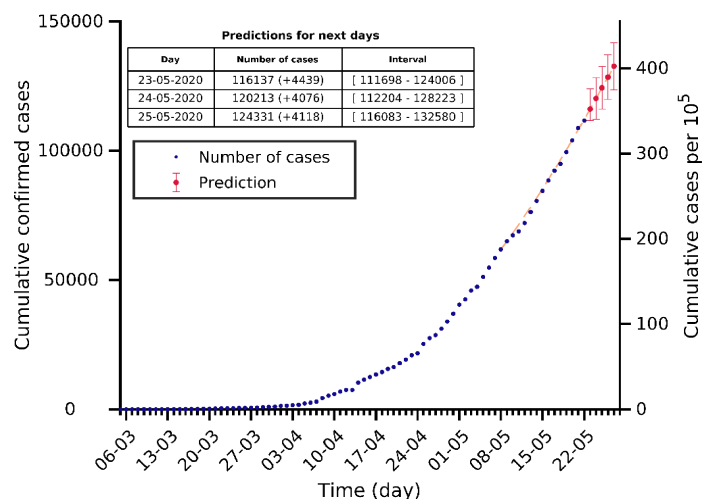
Iran 22-05-2020. Population: 84.0M. Current cumulated incidence: 157/10⁵



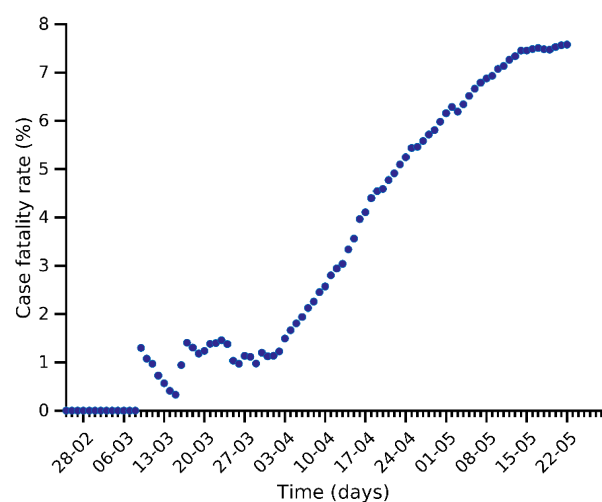
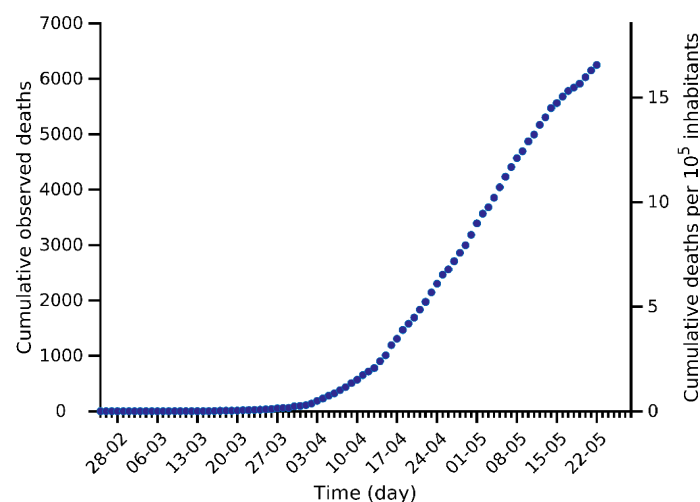
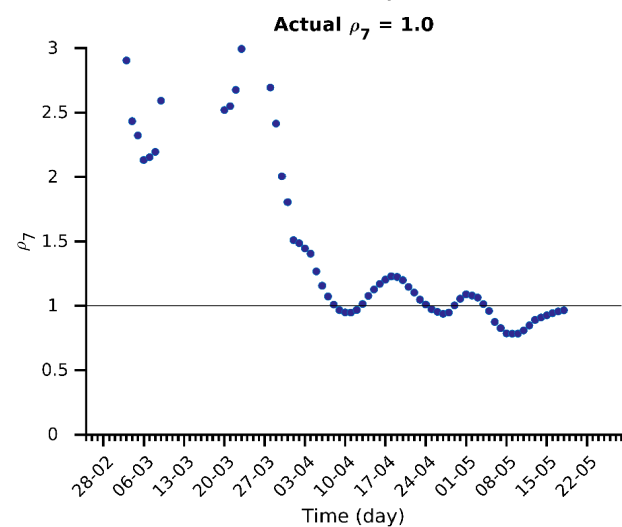
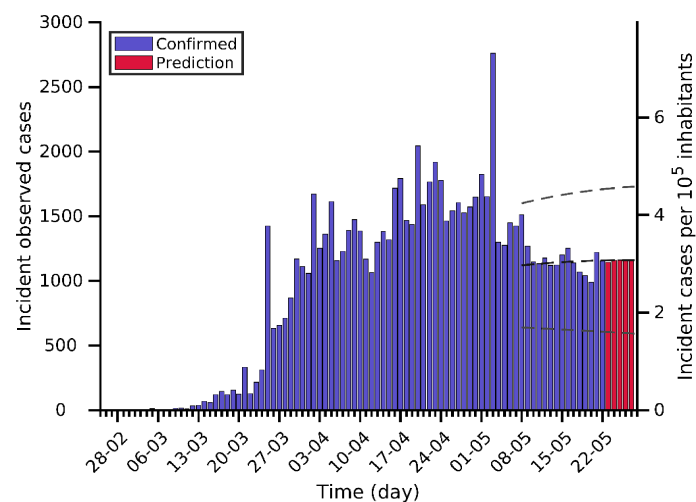
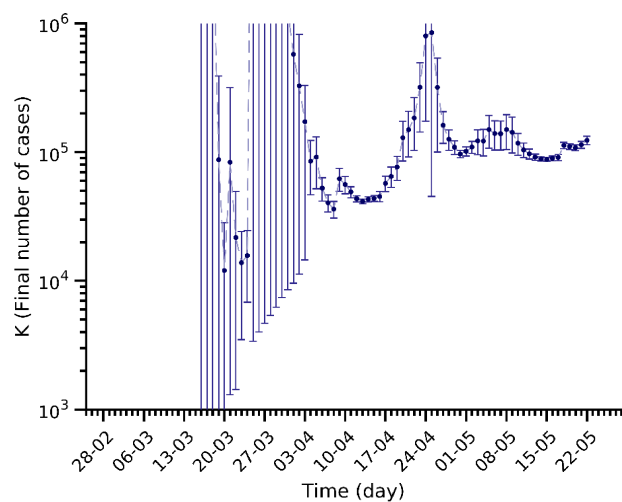
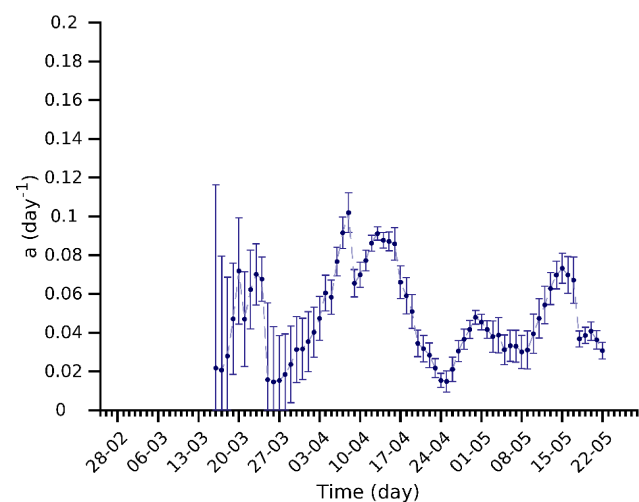
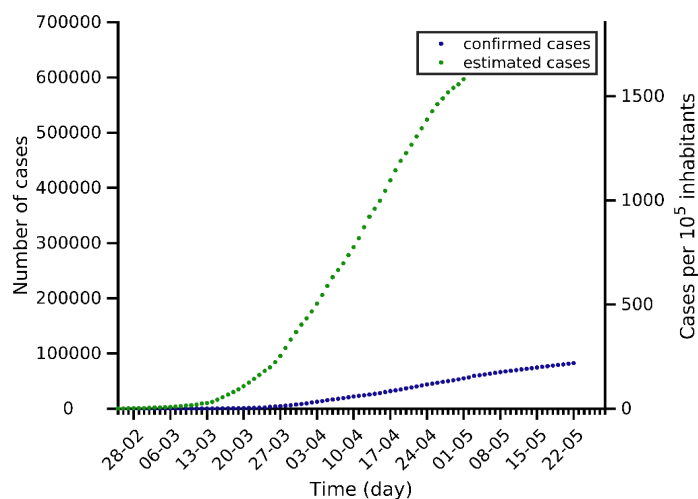
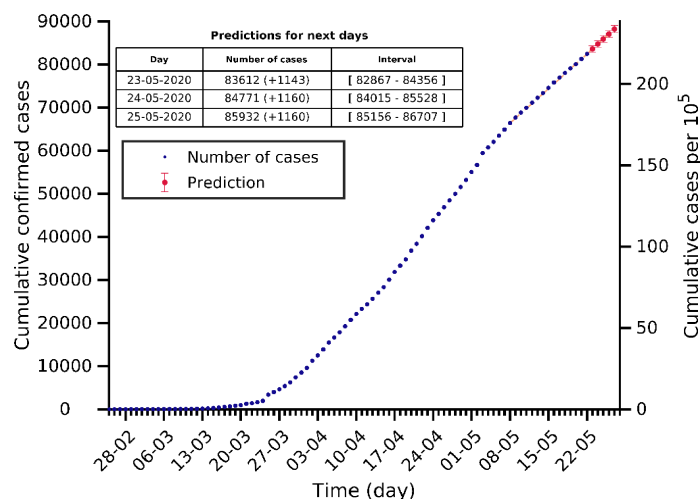
India 22-05-2020. Population: 1353.0M. Current cumulated incidence: 9/10⁵



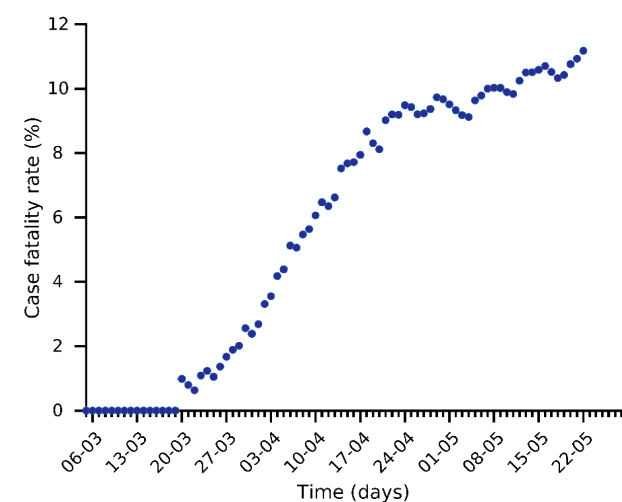
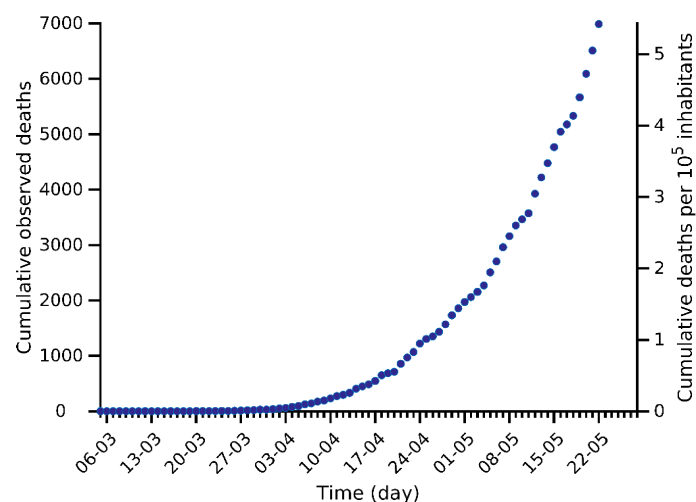
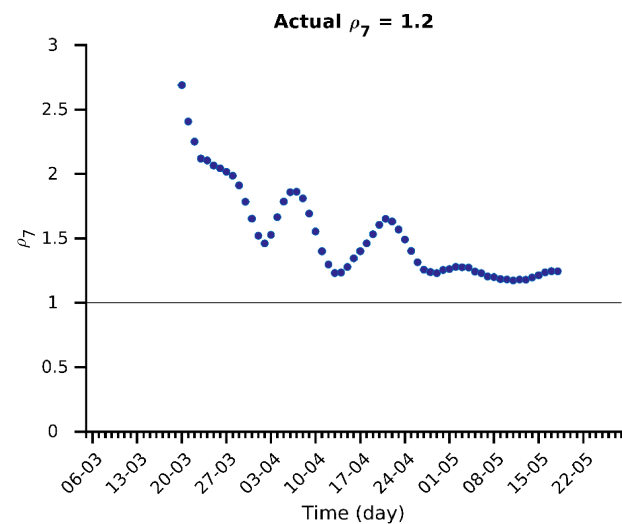
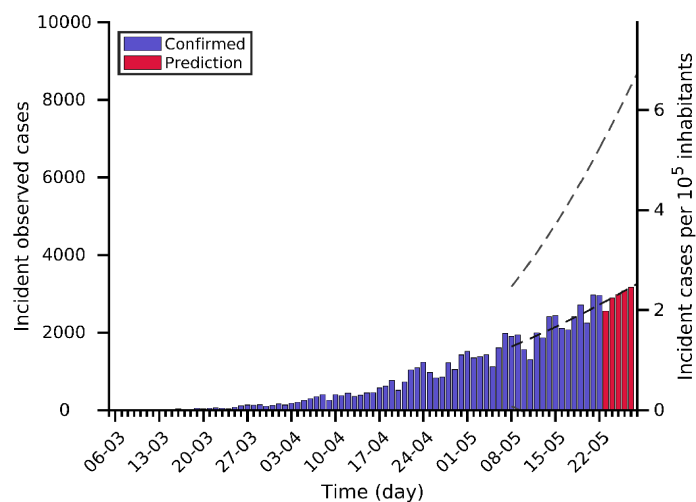
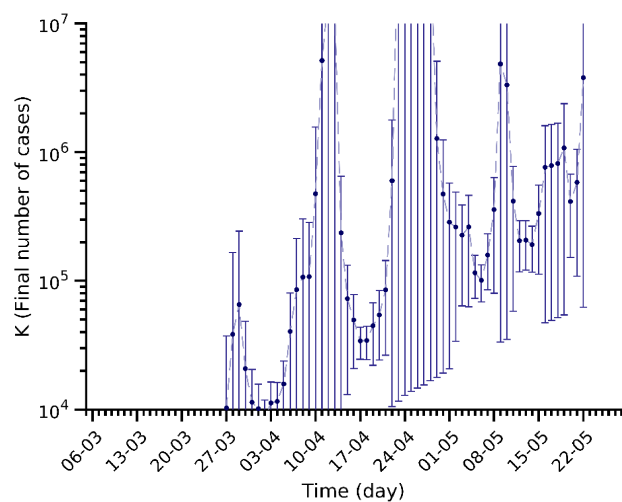
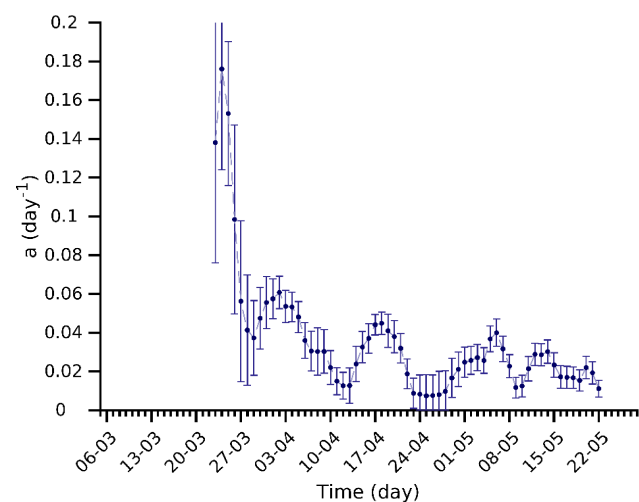
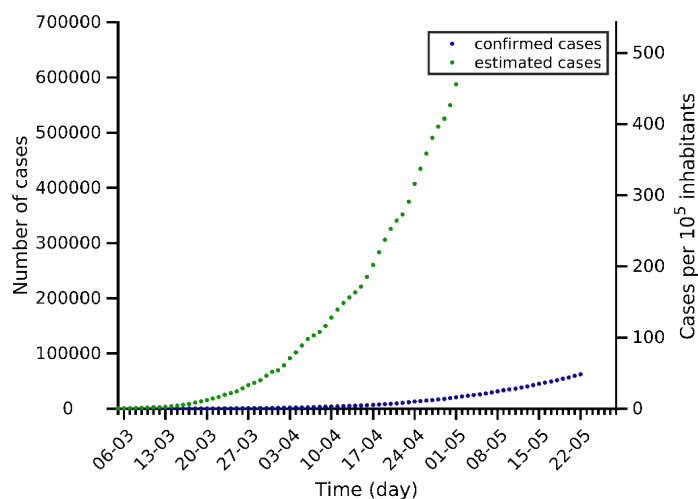
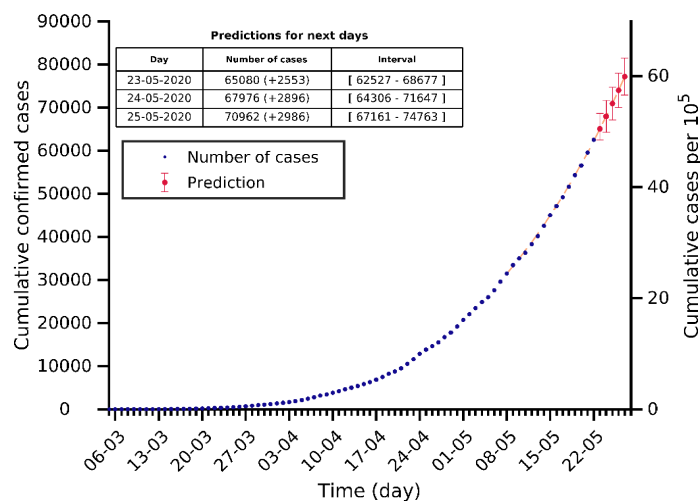
Peru 22-05-2020. Population: 33.0M. Current cumulated incidence: 339/10⁵



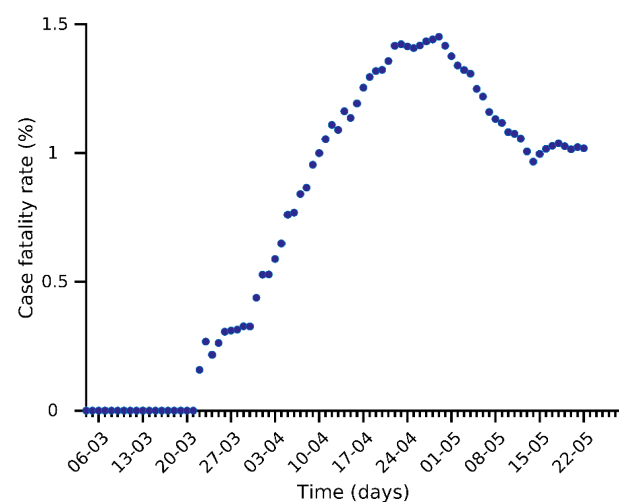
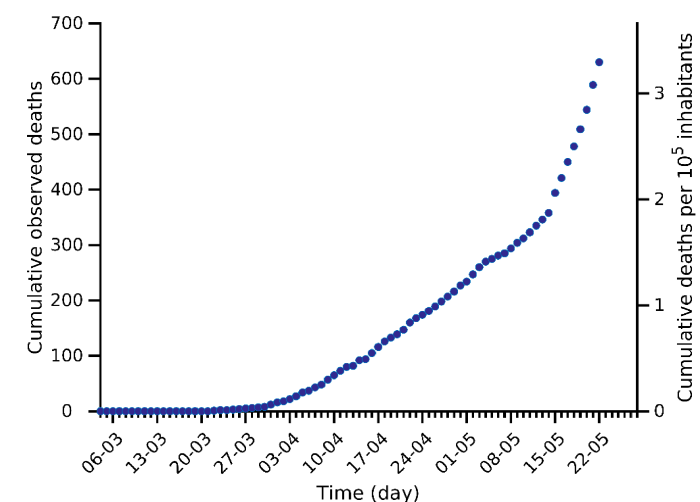
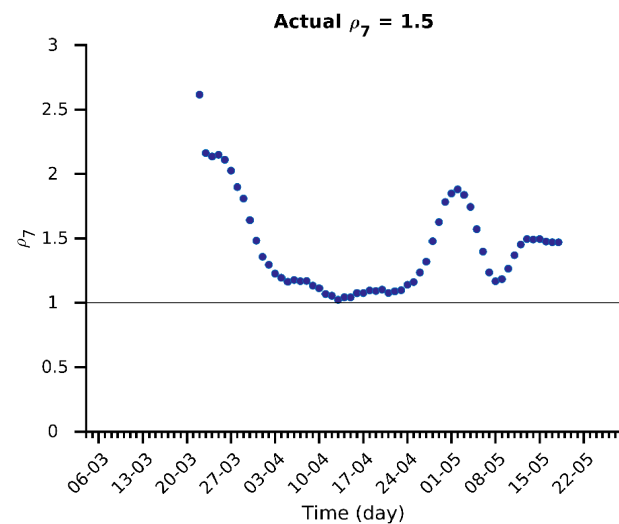
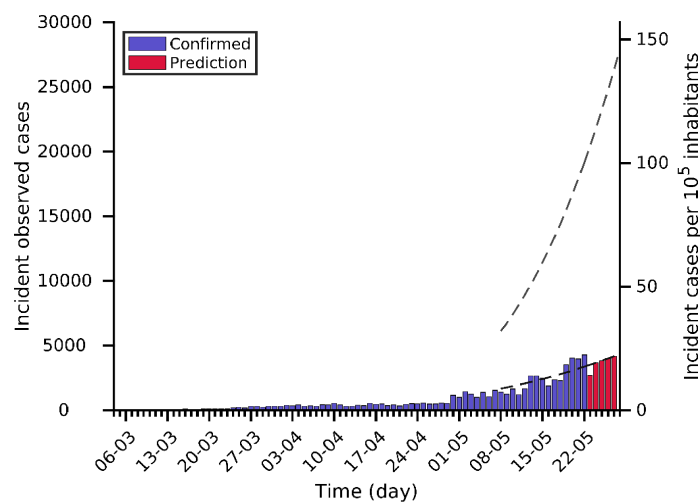
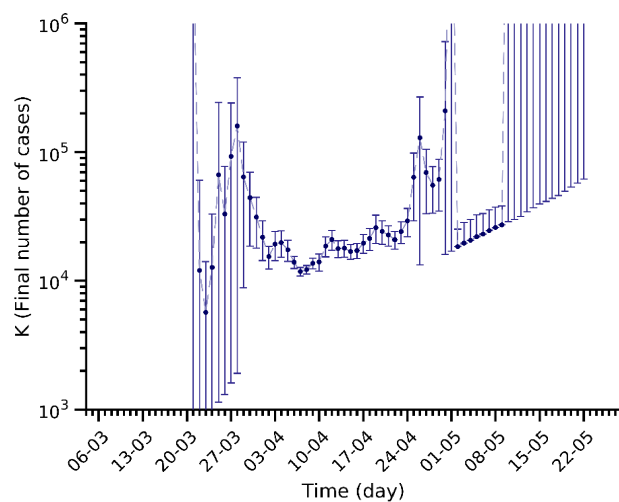
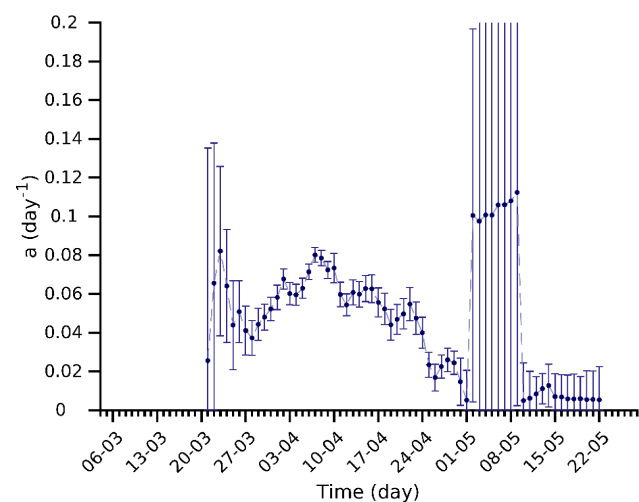
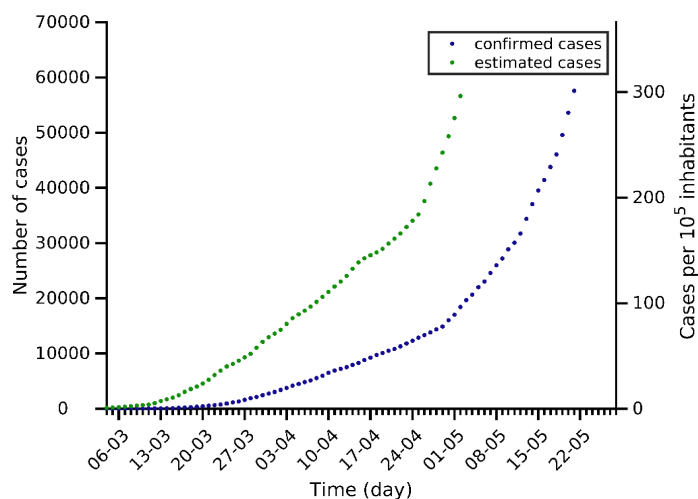
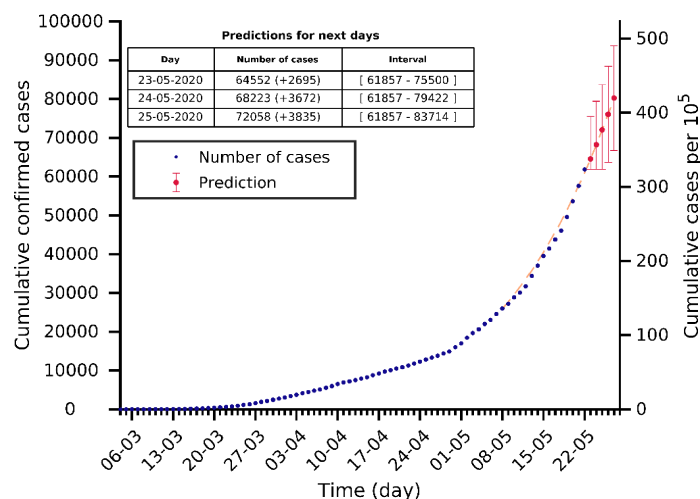
Canada 22-05-2020. Population: 37.7M. Current cumulated incidence: 219/10⁵



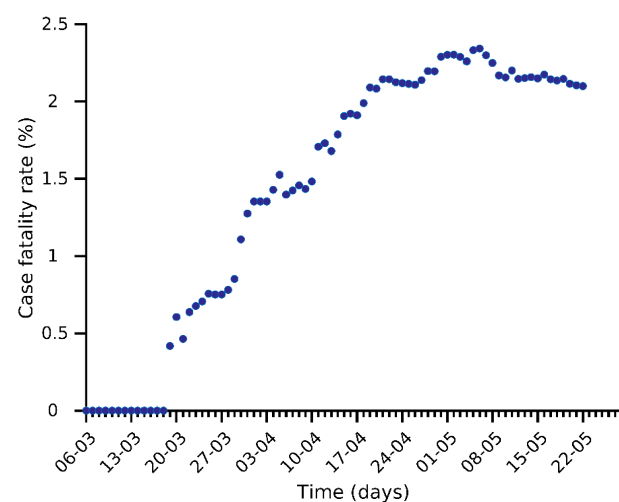
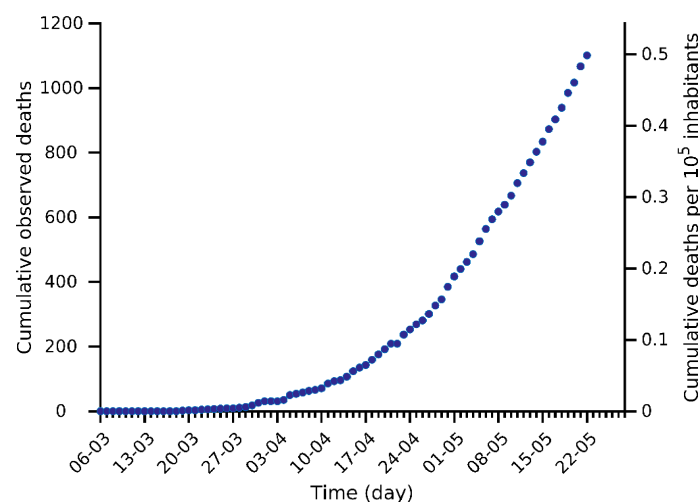
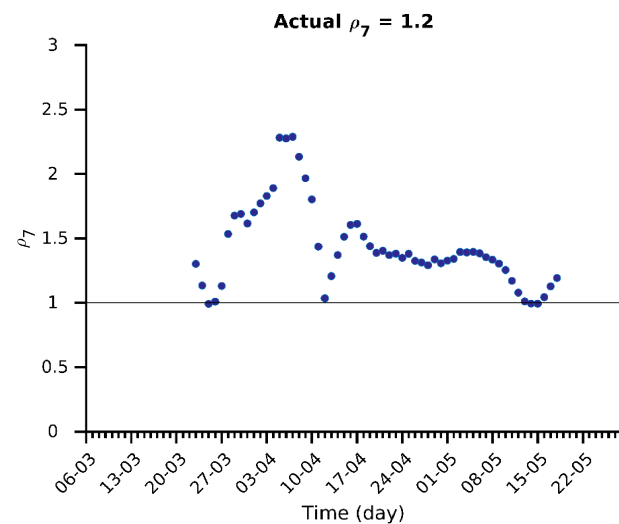
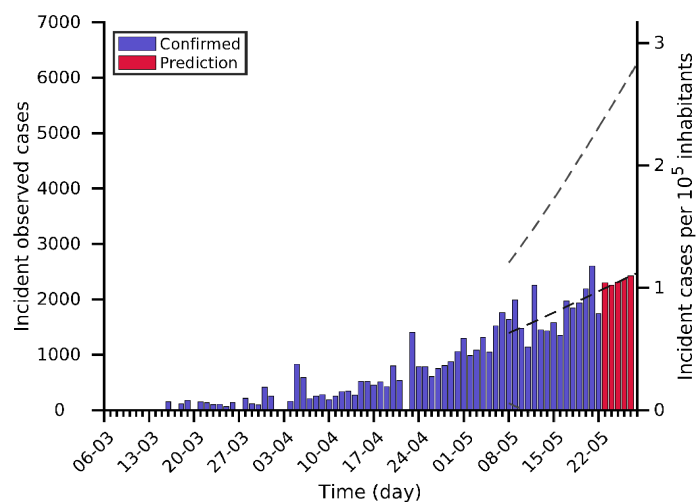
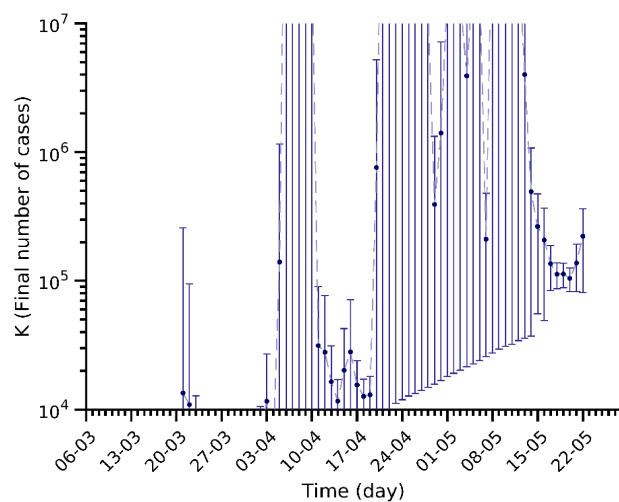
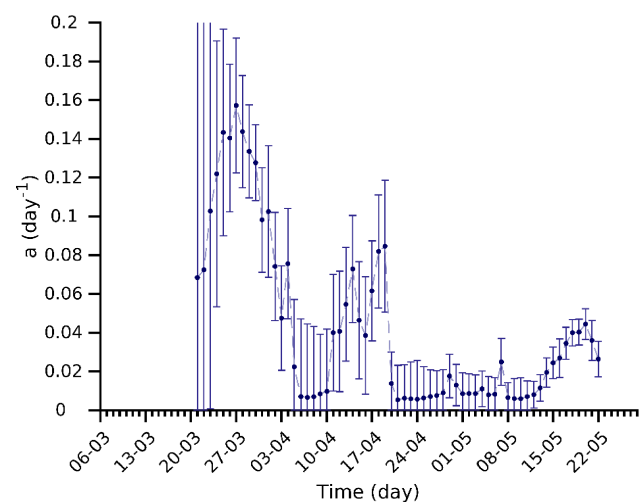
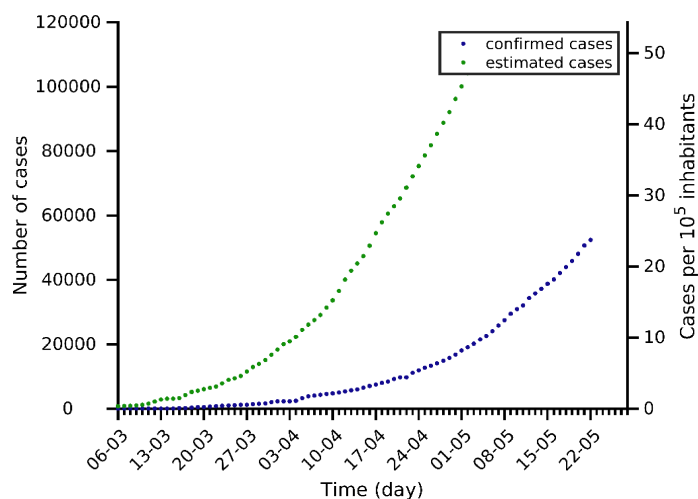
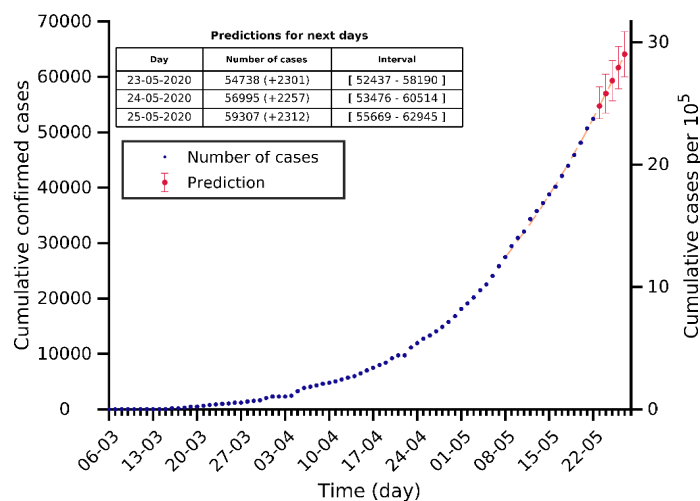
Mexico 22-05-2020. Population: 128.9M. Current cumulated incidence: 48/10⁵



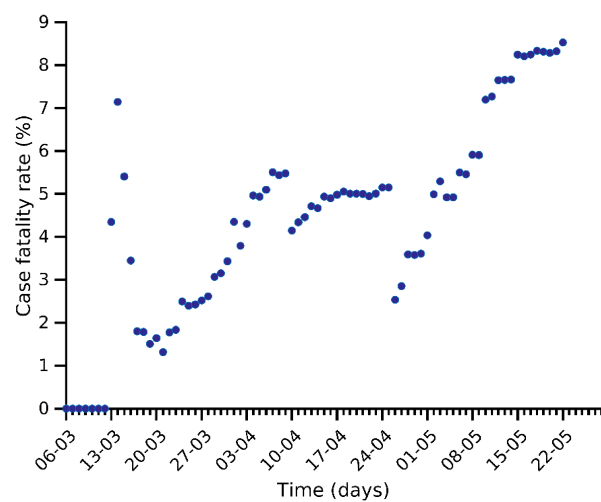
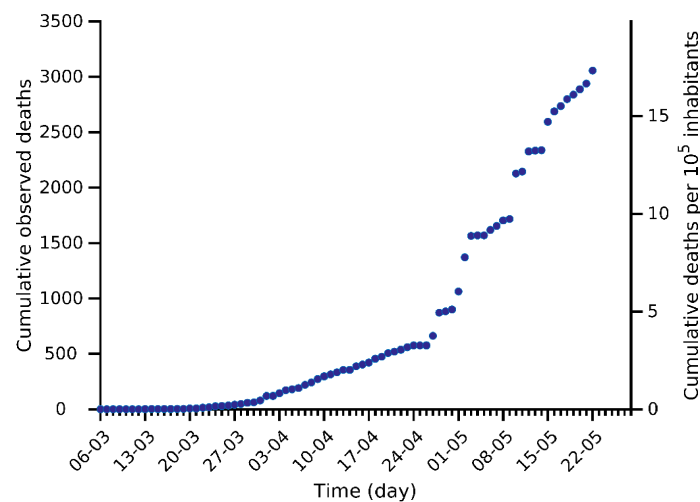
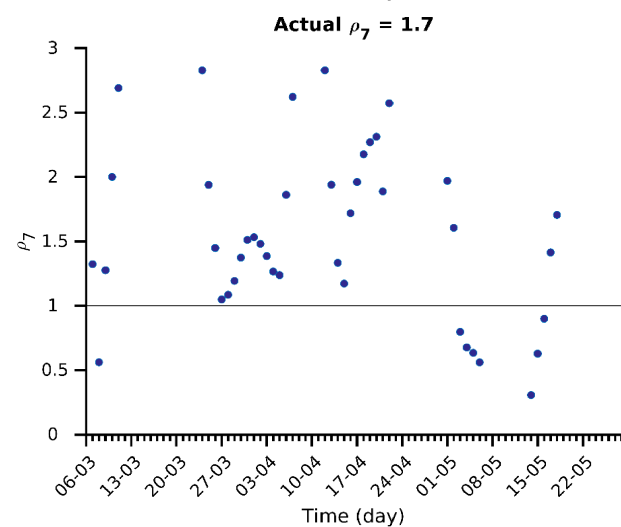
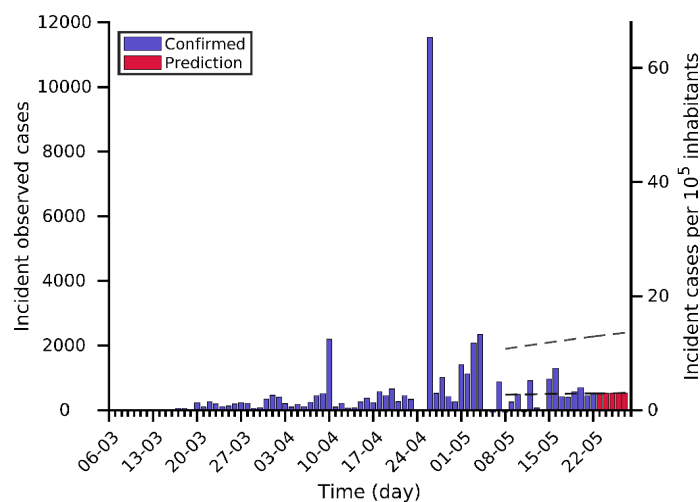
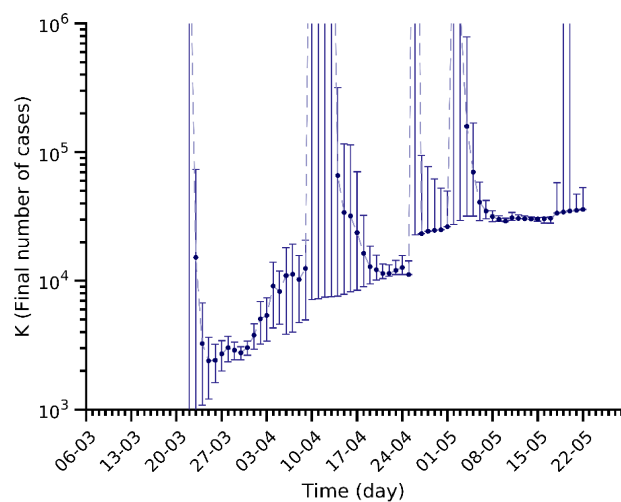
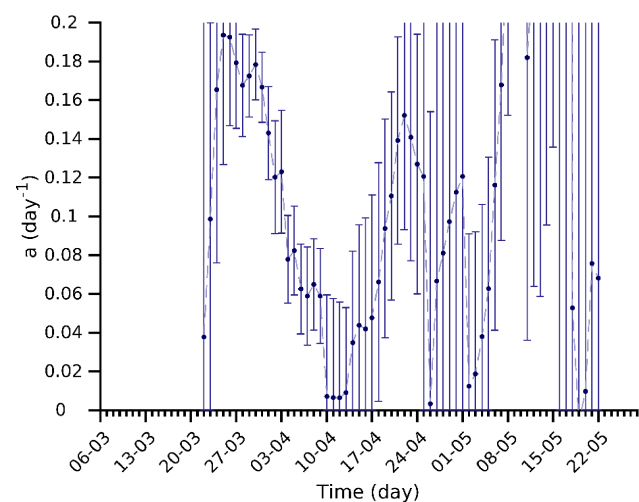
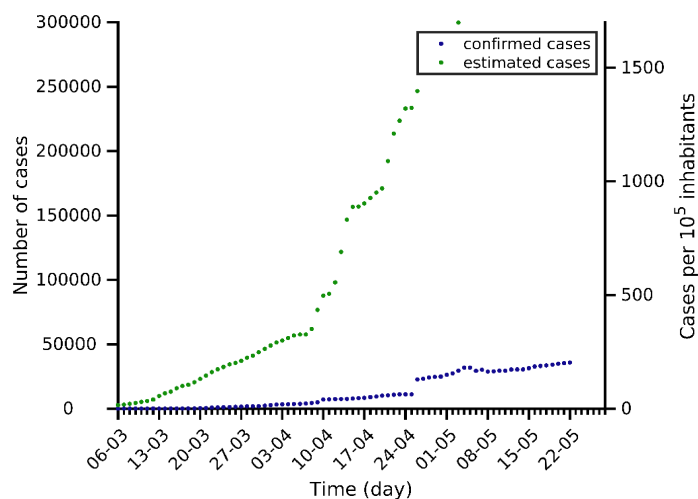
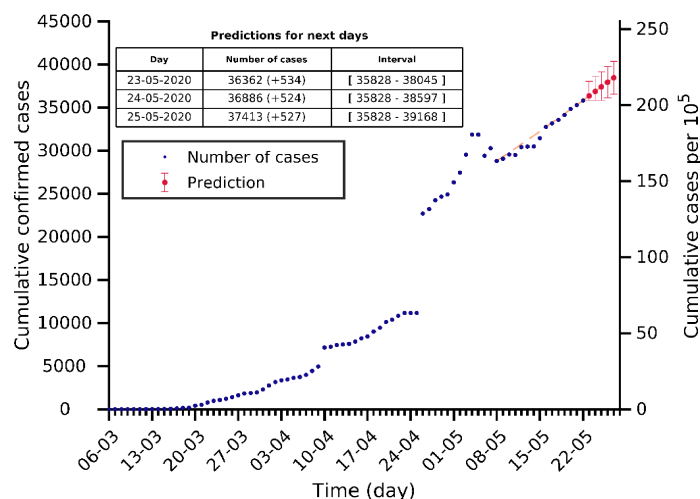
Chile 22-05-2020. Population: 19.1M. Current cumulated incidence: 324/10⁵



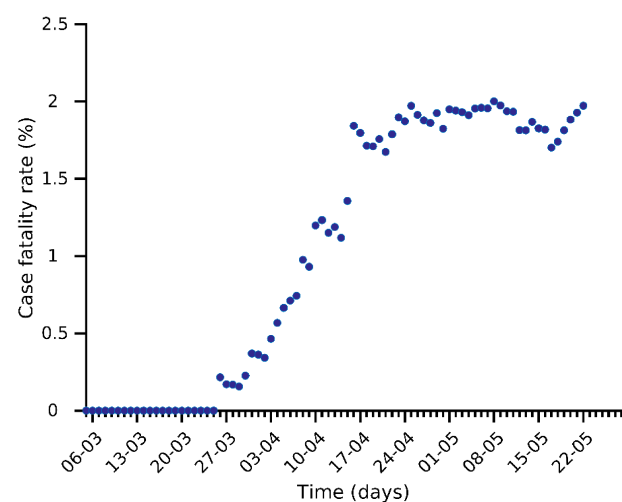
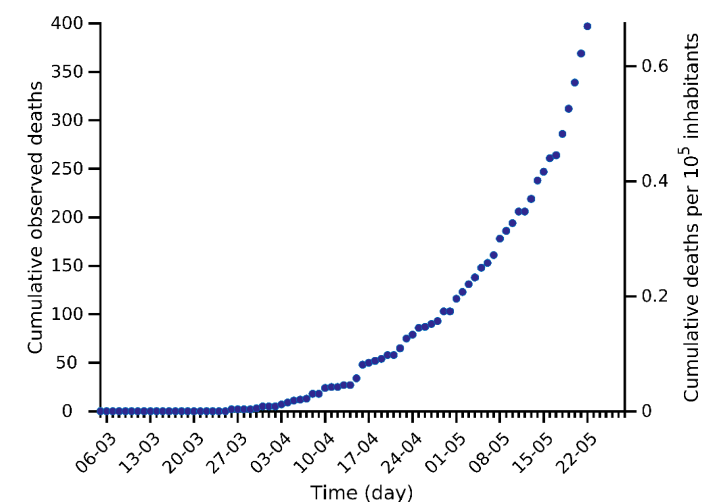
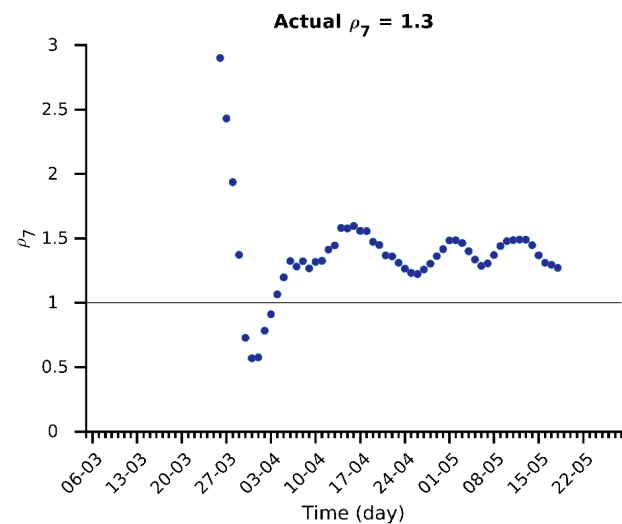
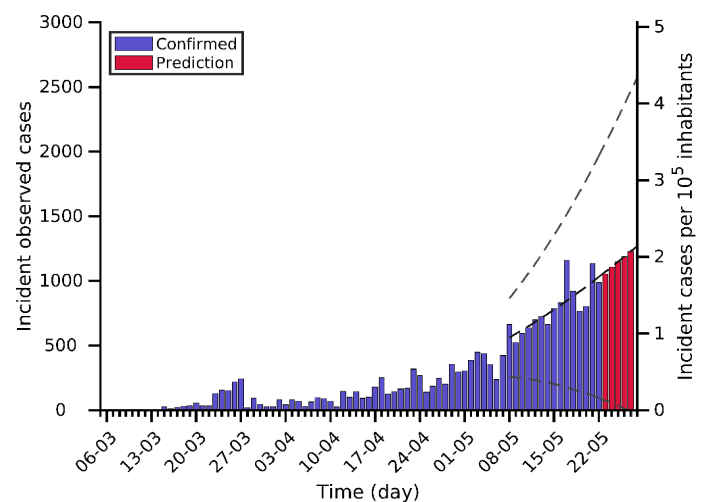
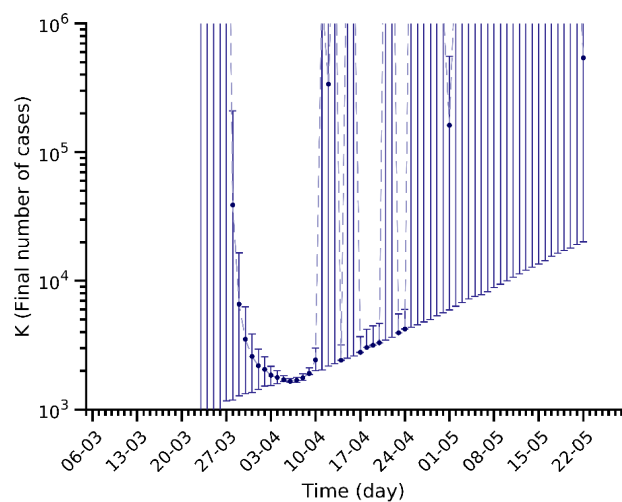
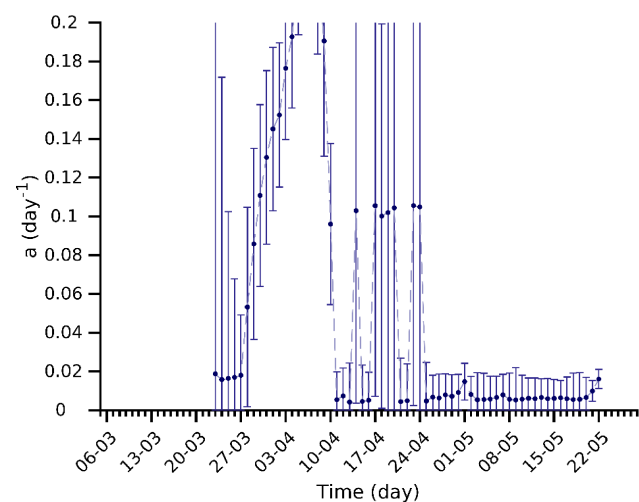
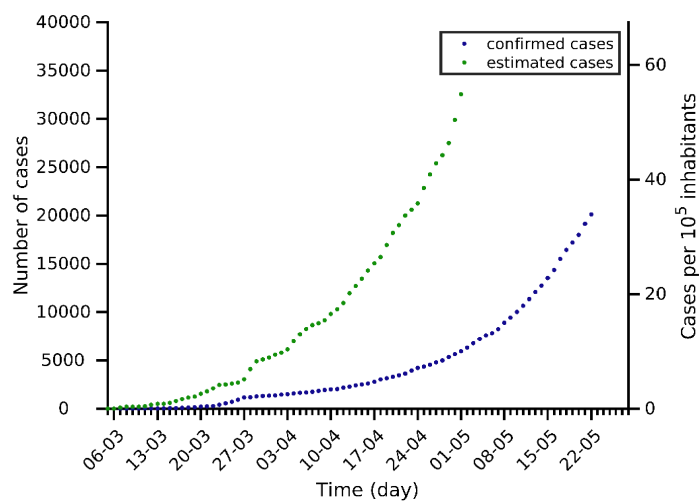
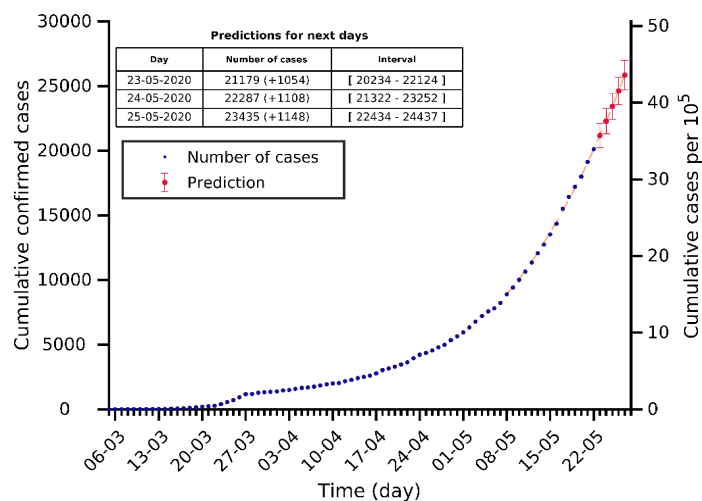
Pakistan 22-05-2020. Population: 220.9M. Current cumulated incidence: 24/10⁵



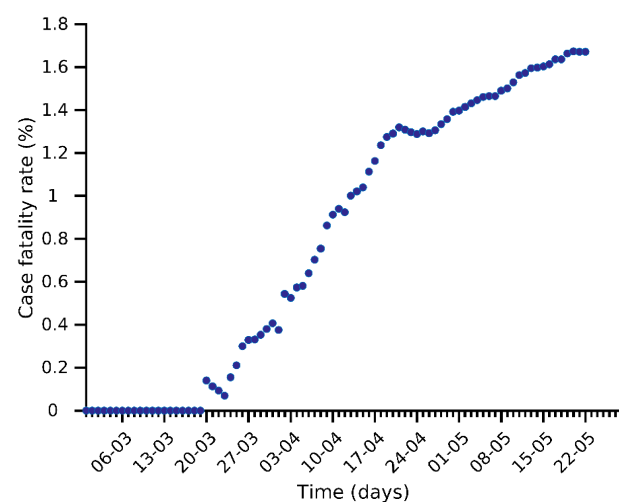
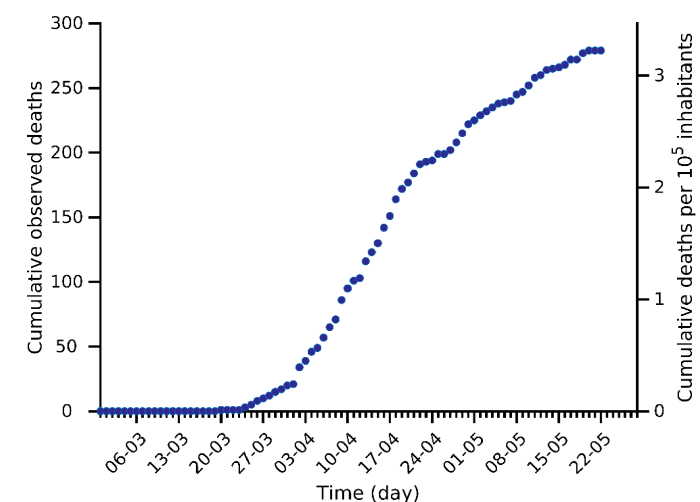
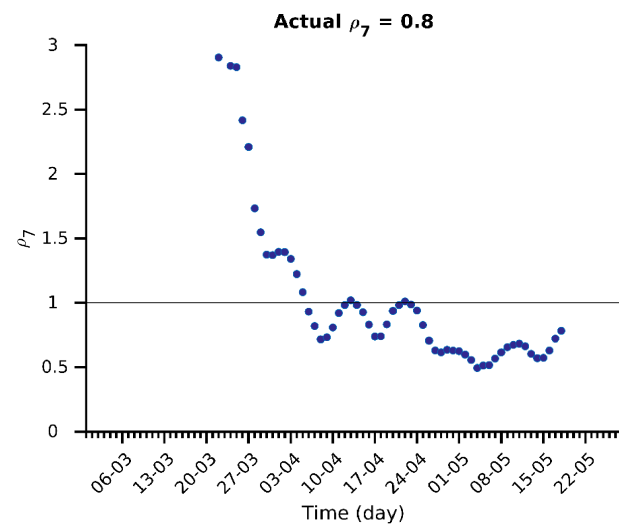
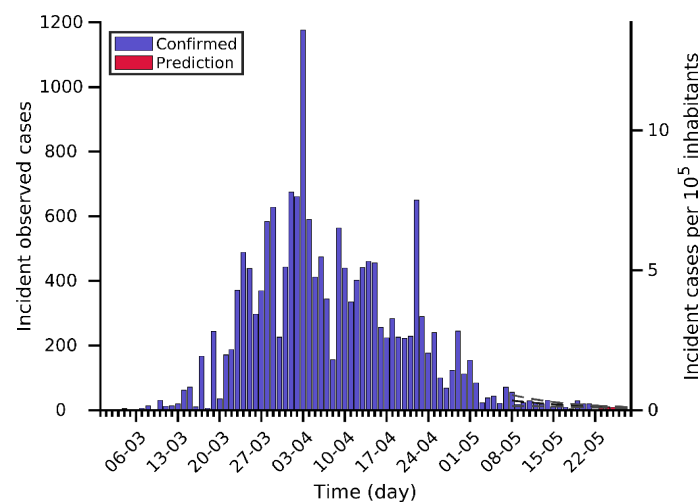
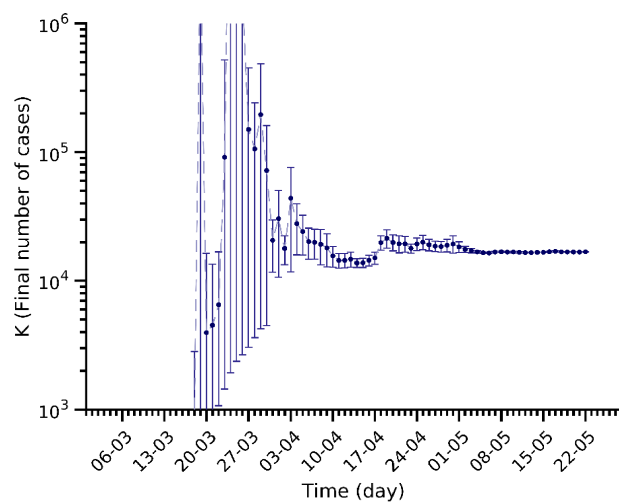
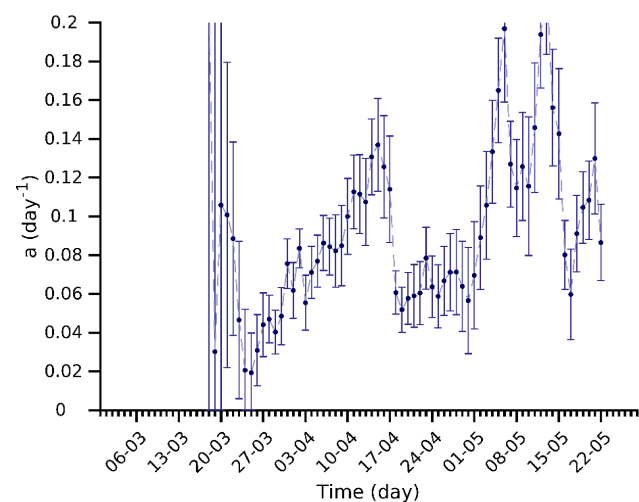
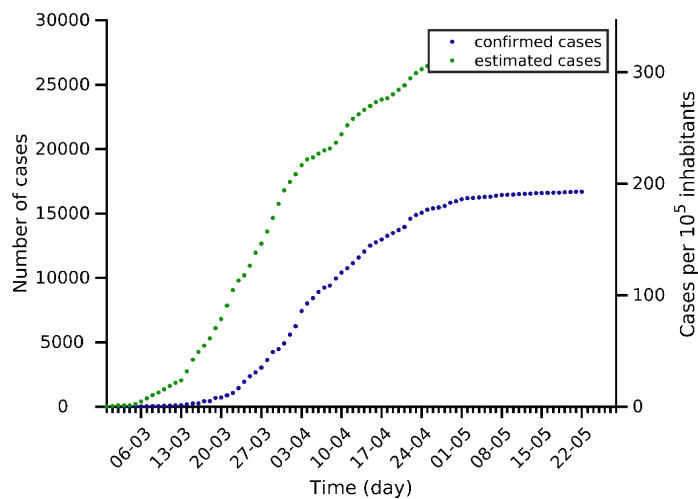
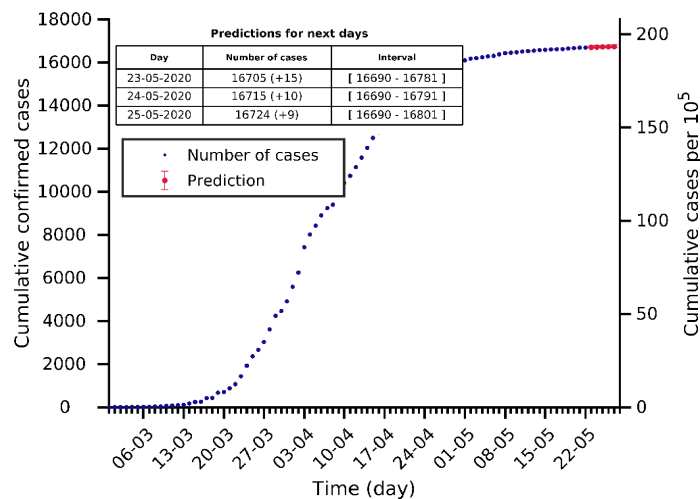
Ecuador 22-05-2020. Population: 17.6M. Current cumulated incidence: 203/10⁵



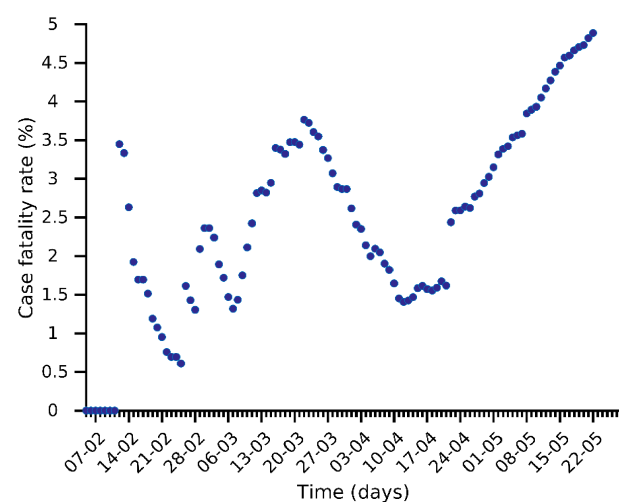
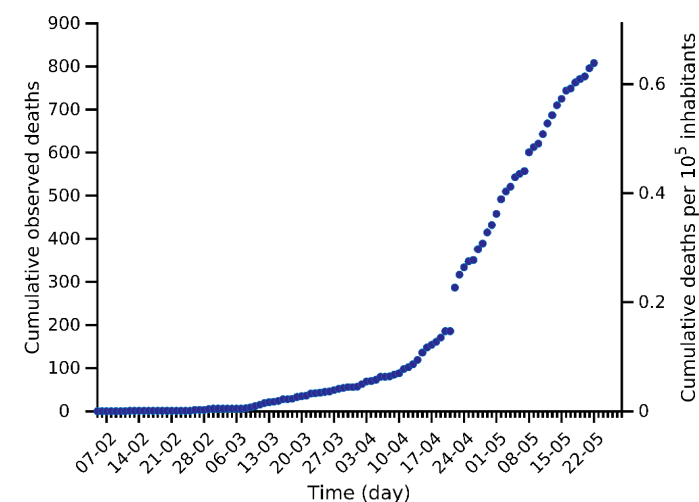
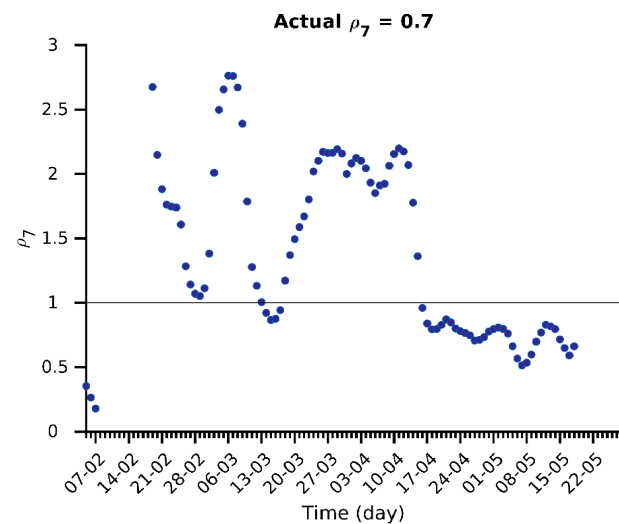
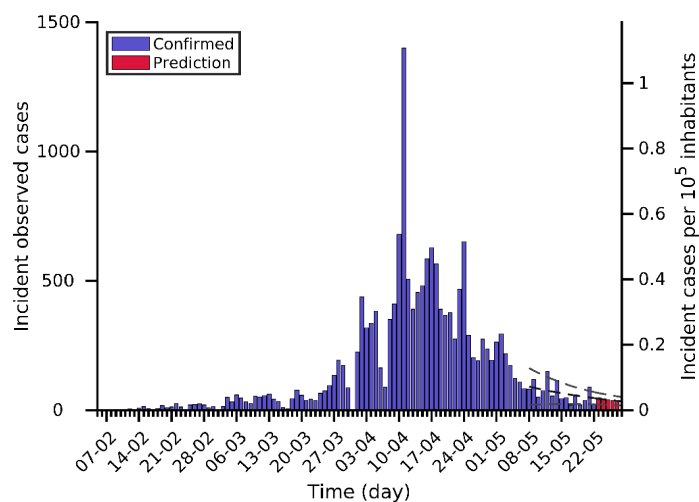
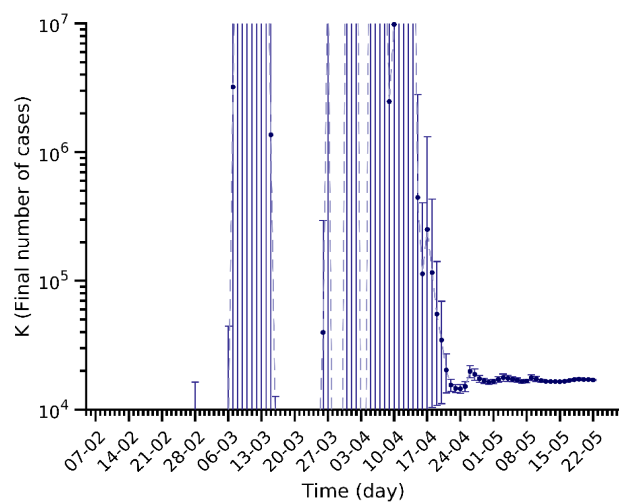
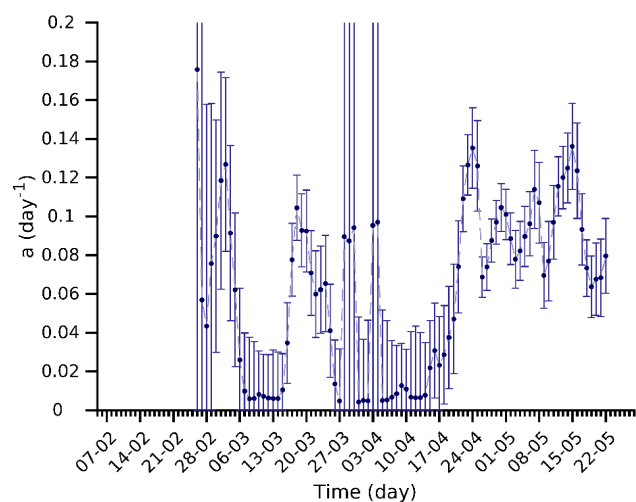
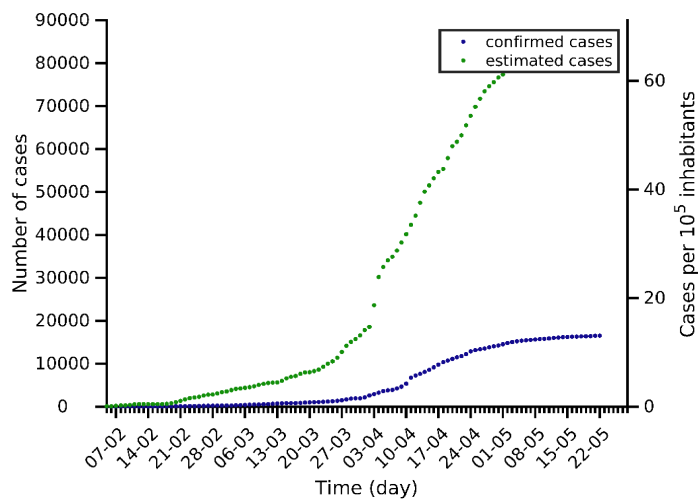
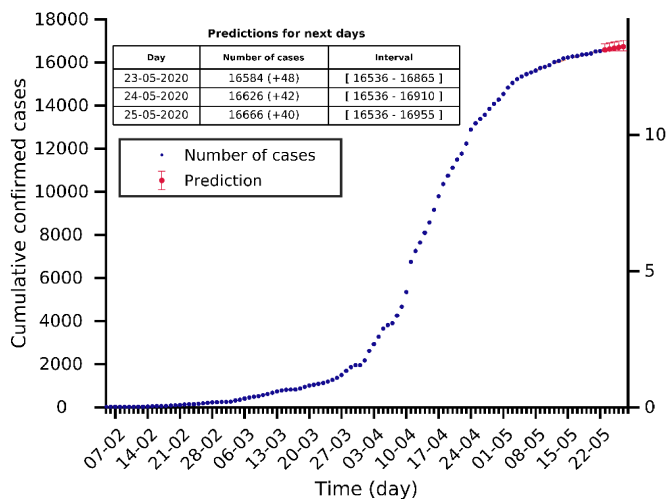
South Africa 22-05-2020. Population: 59.3M. Current cumulated incidence: 34/10⁵



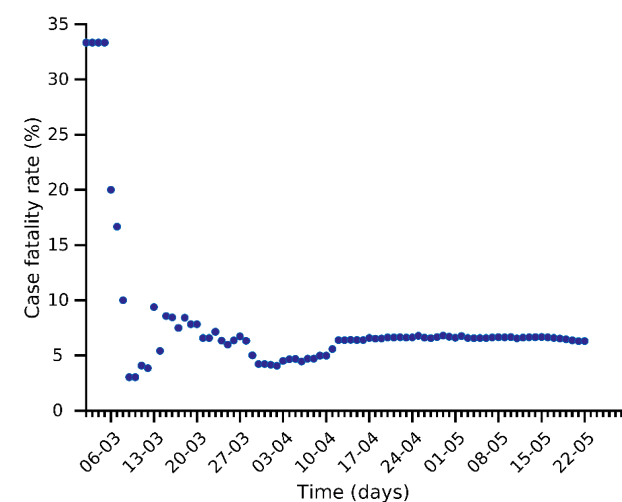
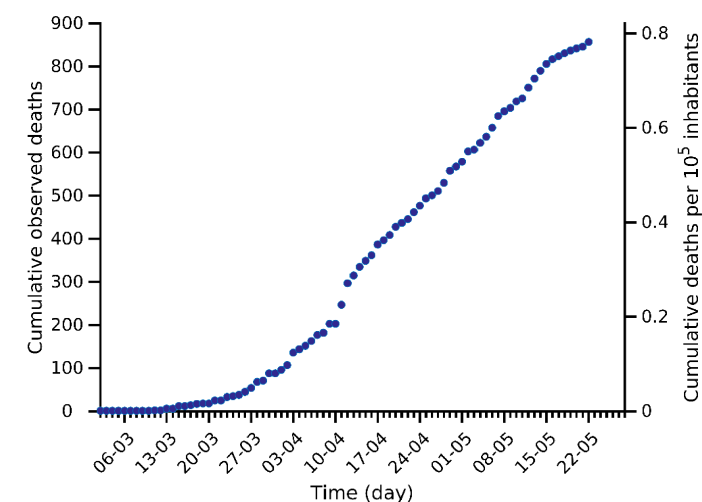
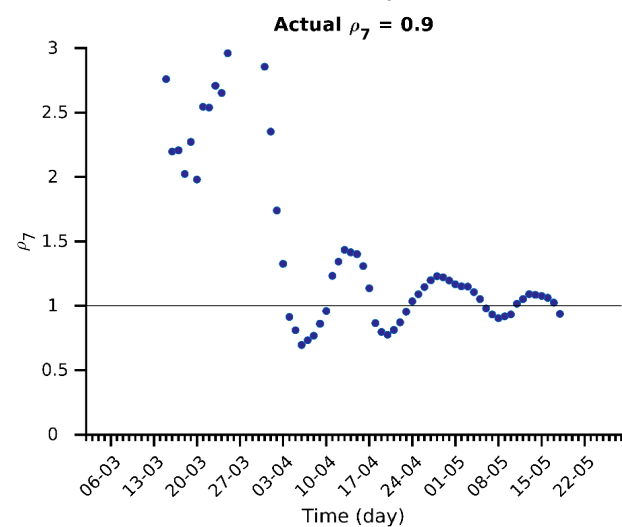
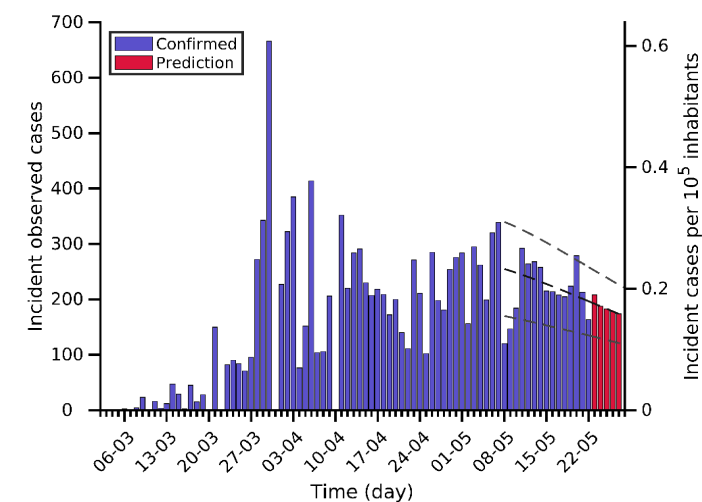
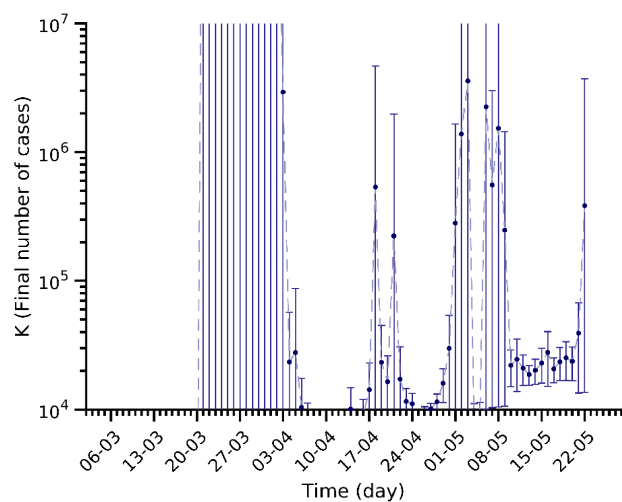
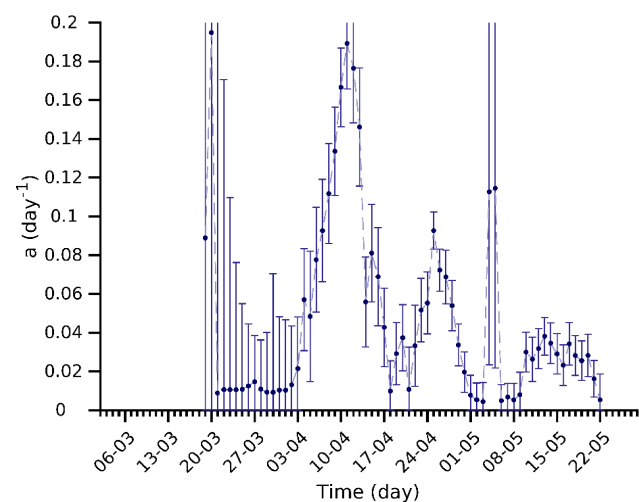
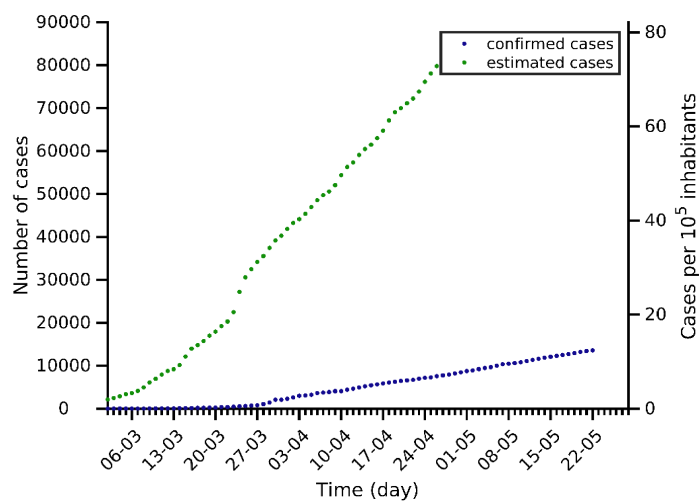
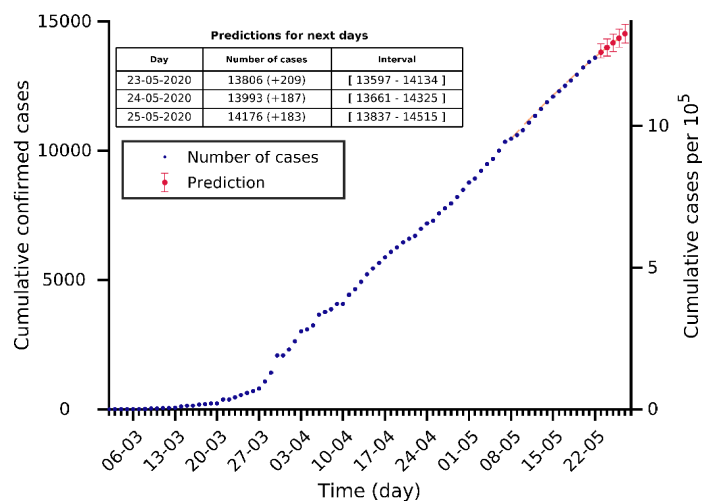
Israel 22-05-2020. Population: 8.7M. Current cumulated incidence: 193/10⁵



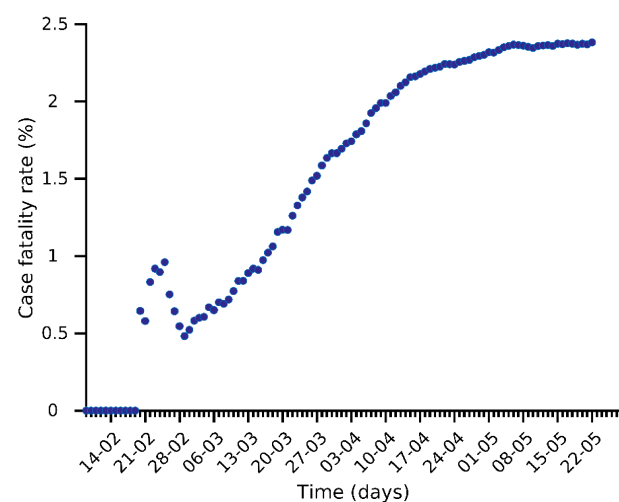
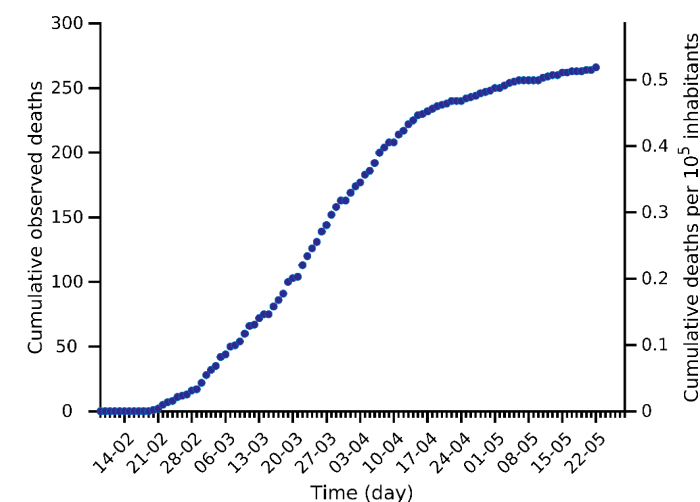
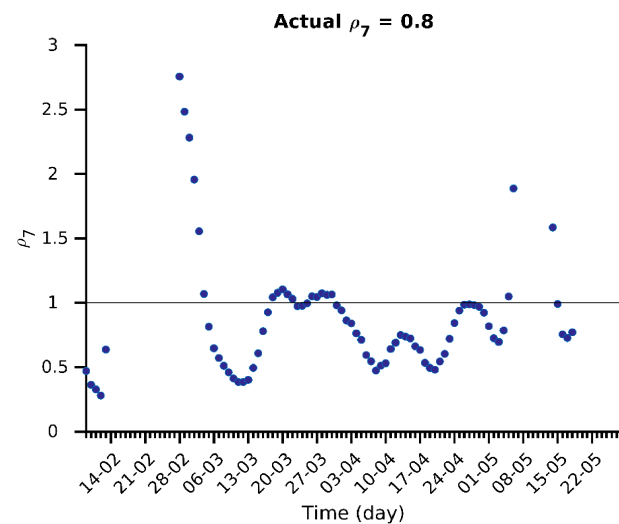
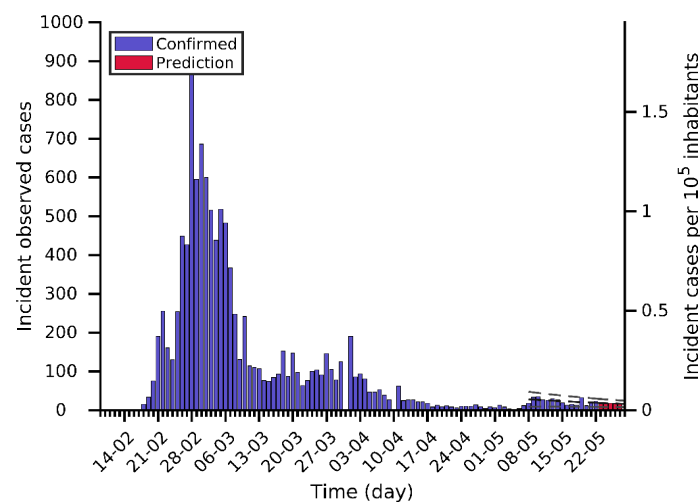
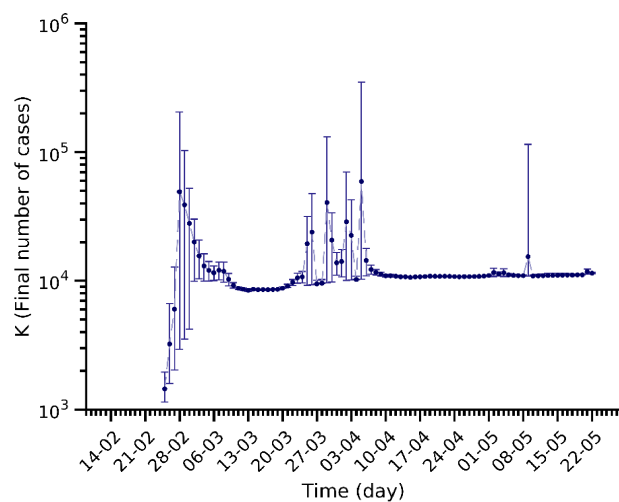
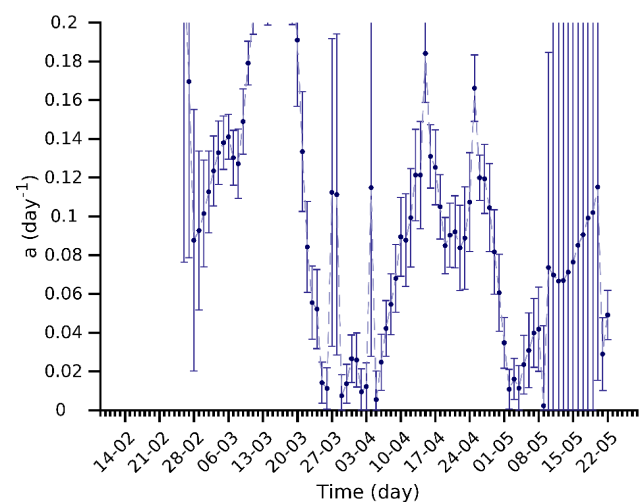
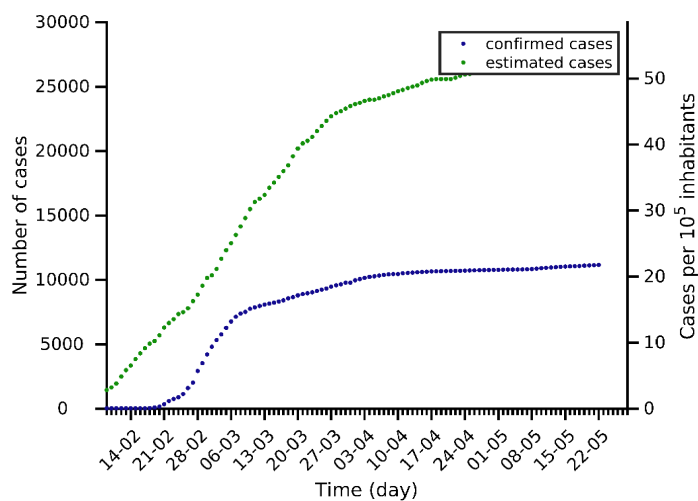
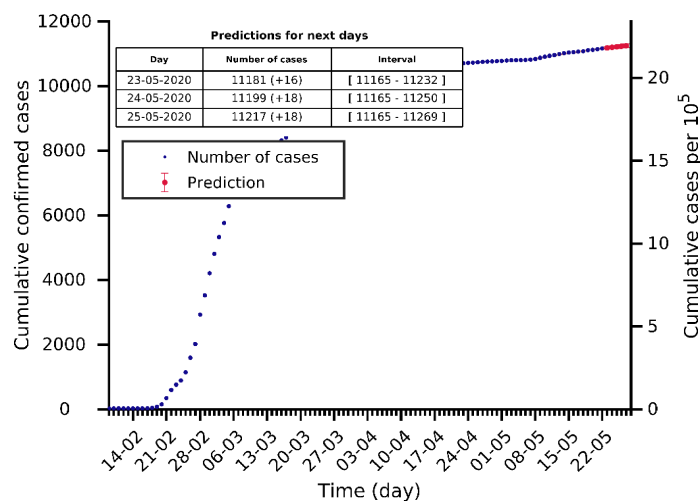
Japan 22-05-2020. Population: 126.5M. Current cumulated incidence: 13/10⁵



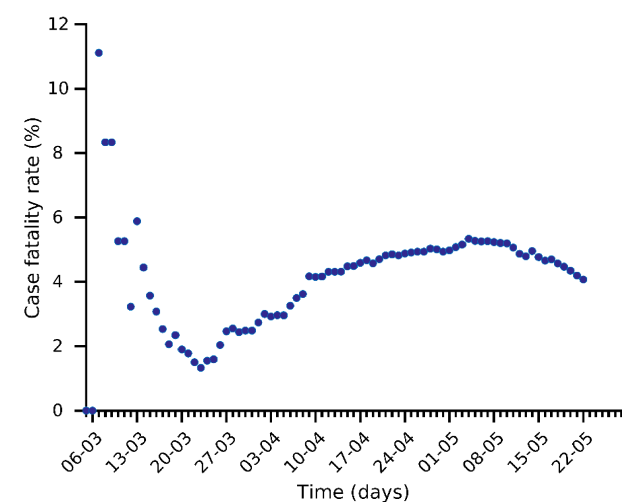
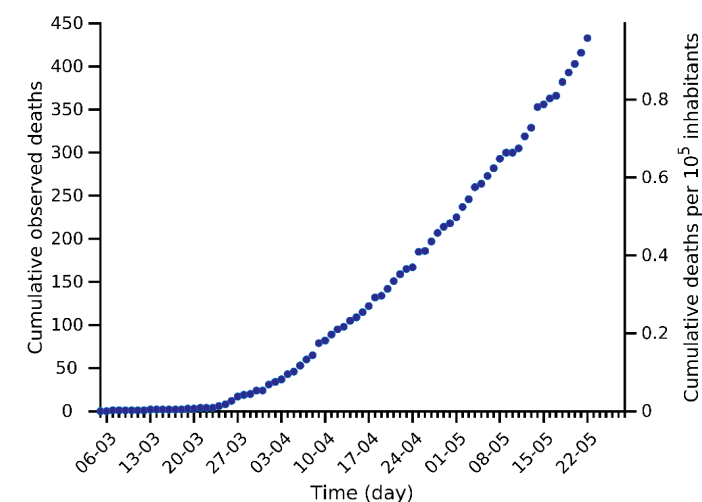
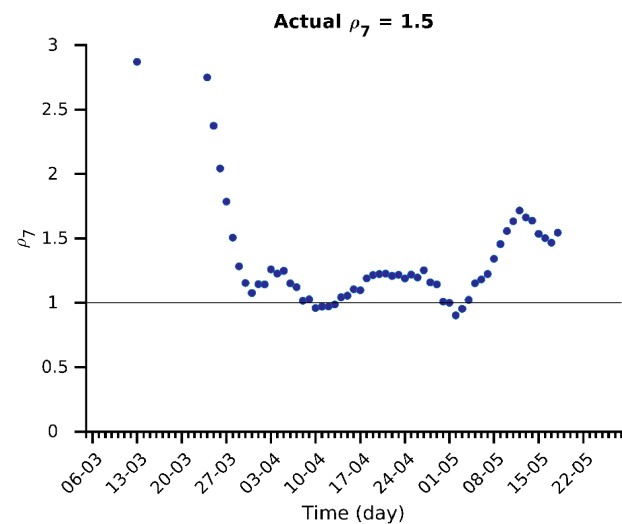
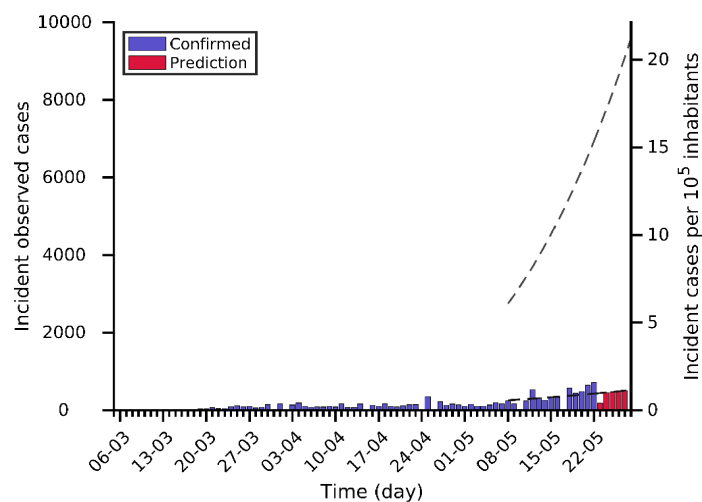
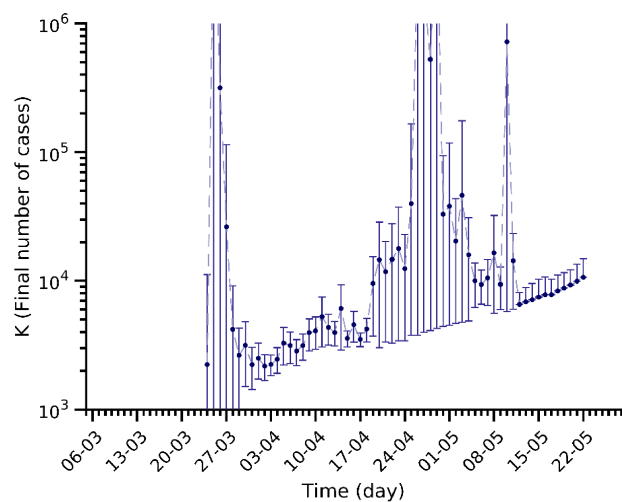
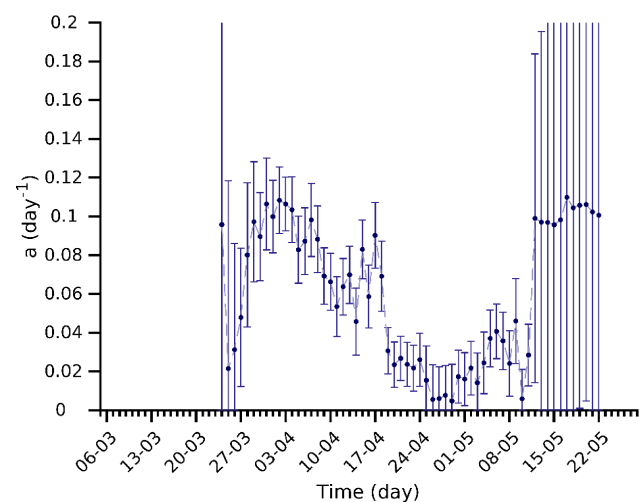
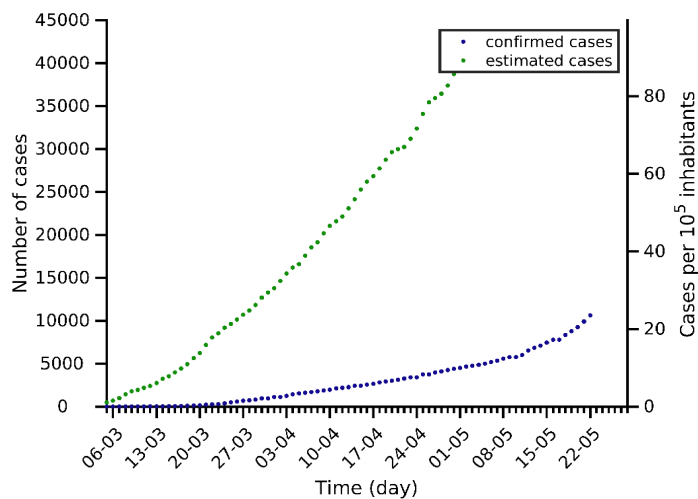
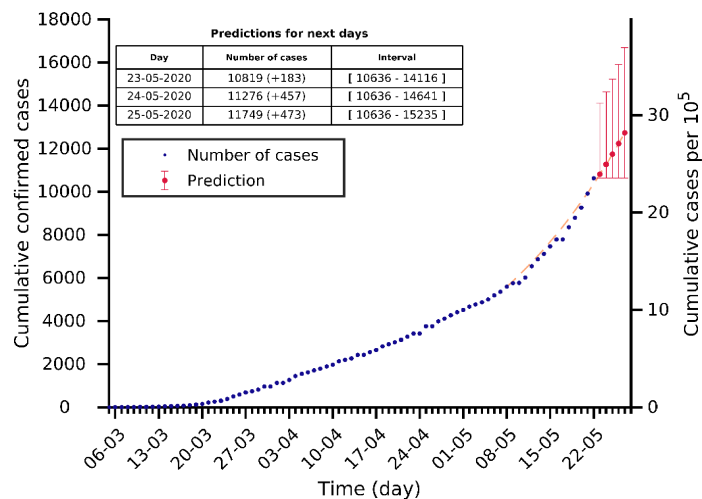
Philippines 22-05-2020. Population: 109.6M. Current cumulated incidence: 12/10⁵



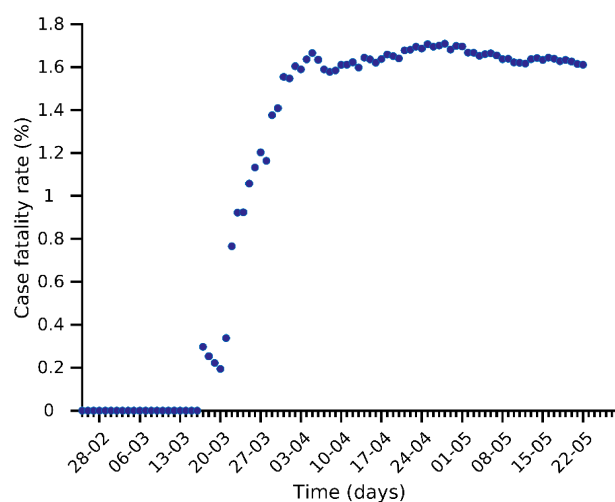
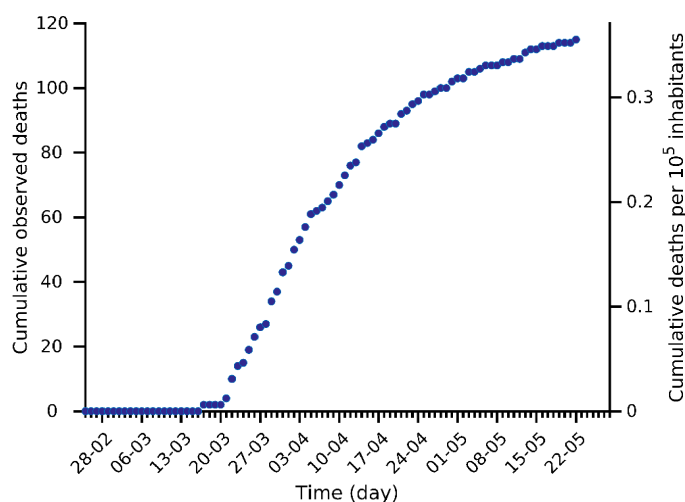
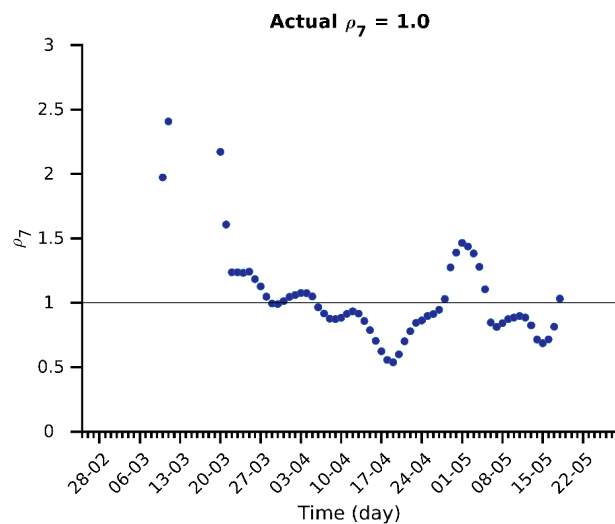
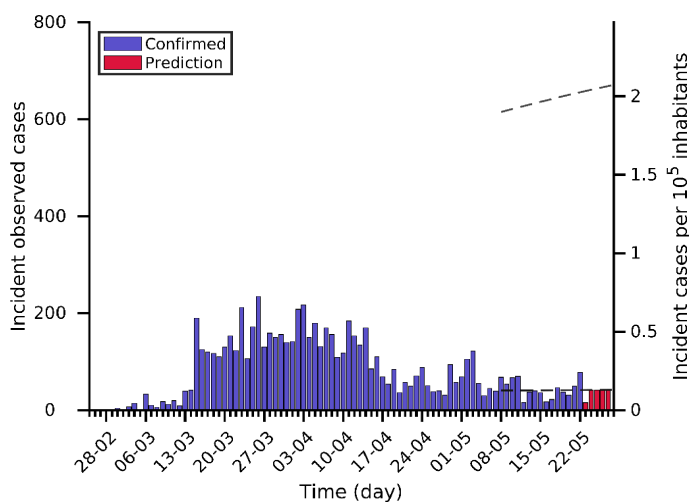
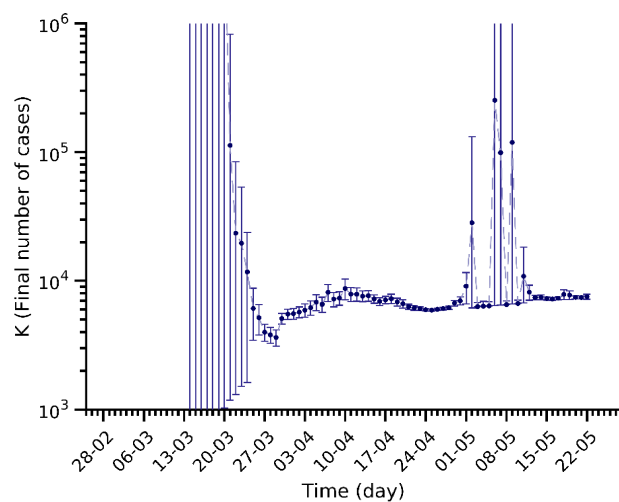
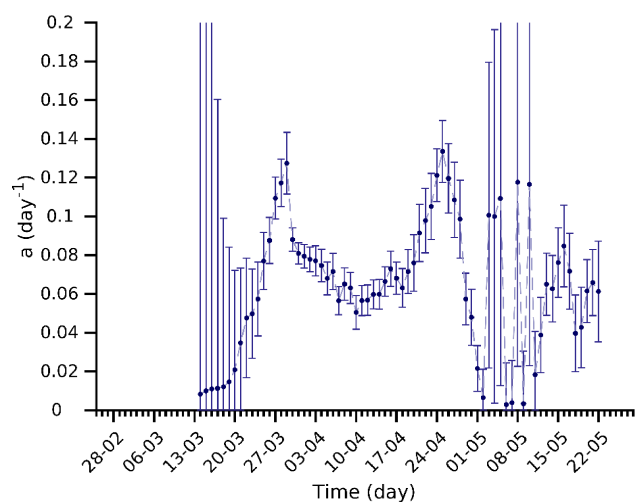
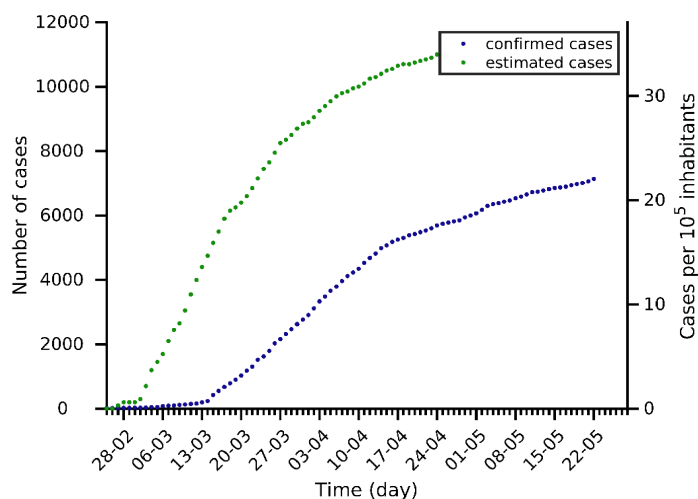
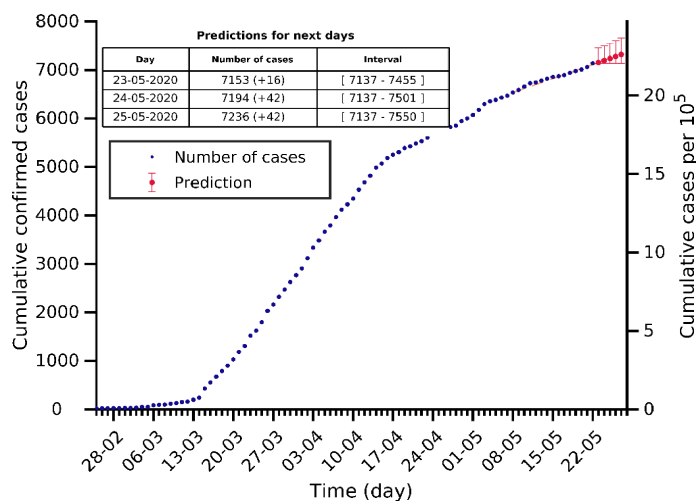
South Korea 22-05-2020. Population: 51.3M. Current cumulated incidence: 22/10⁵



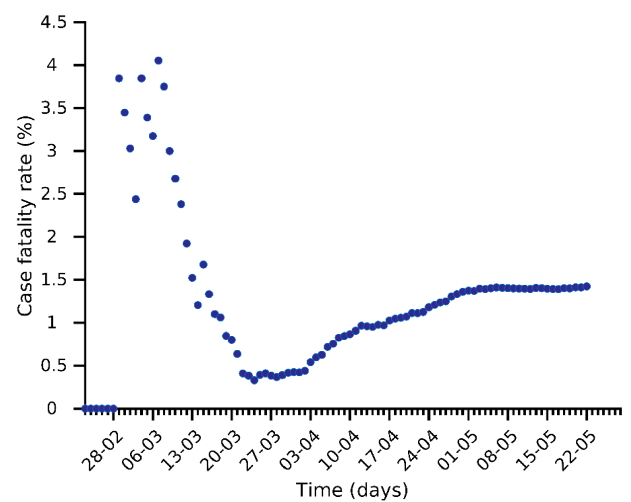
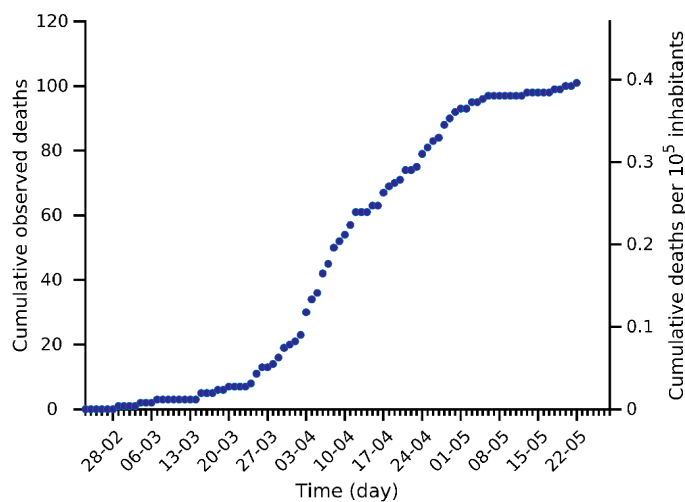
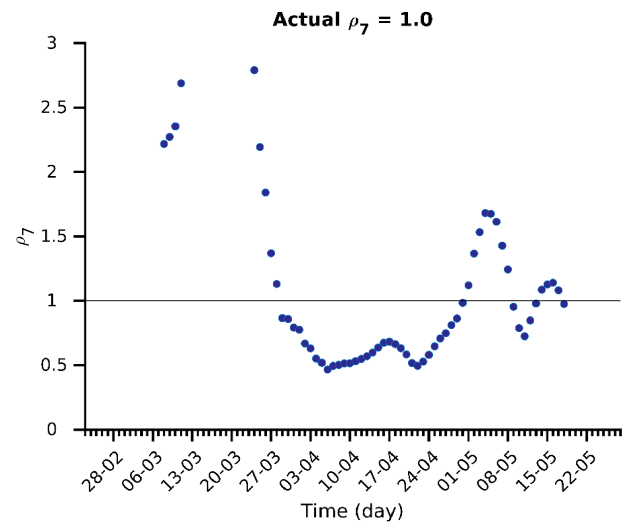
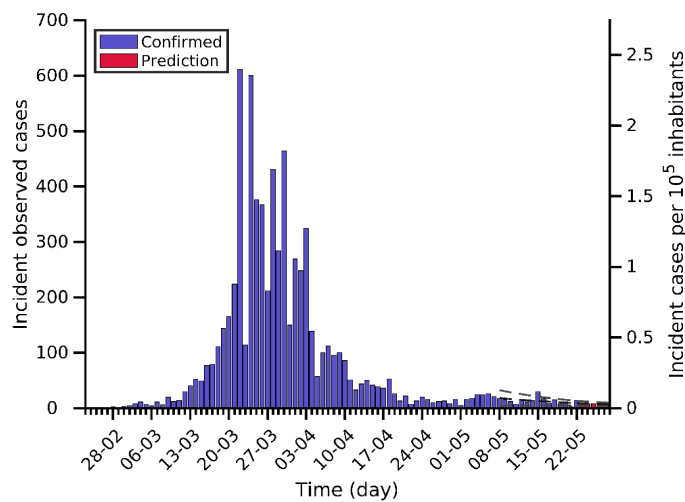
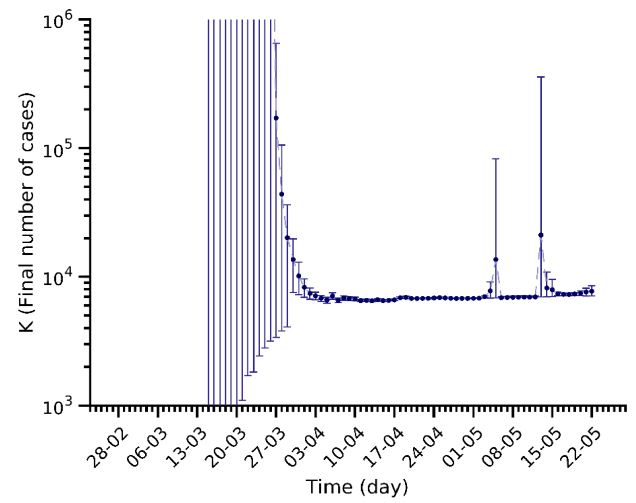
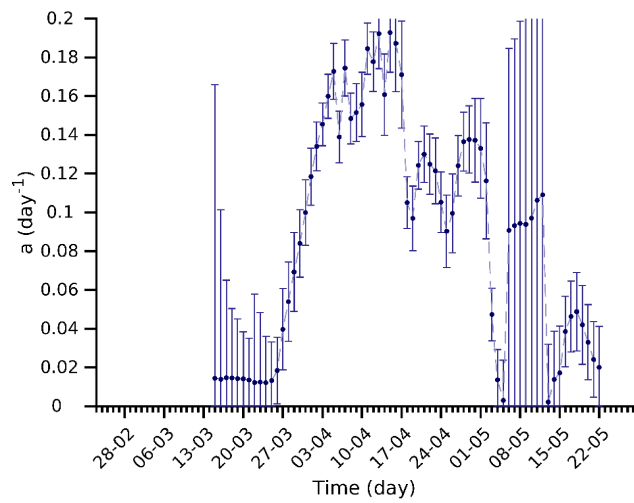
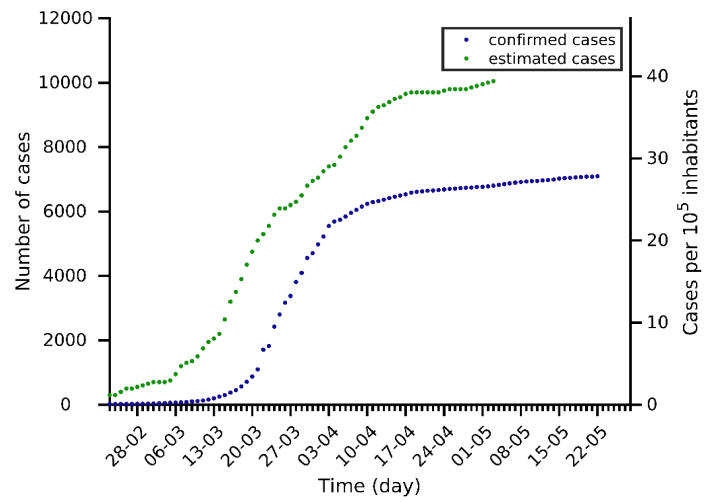
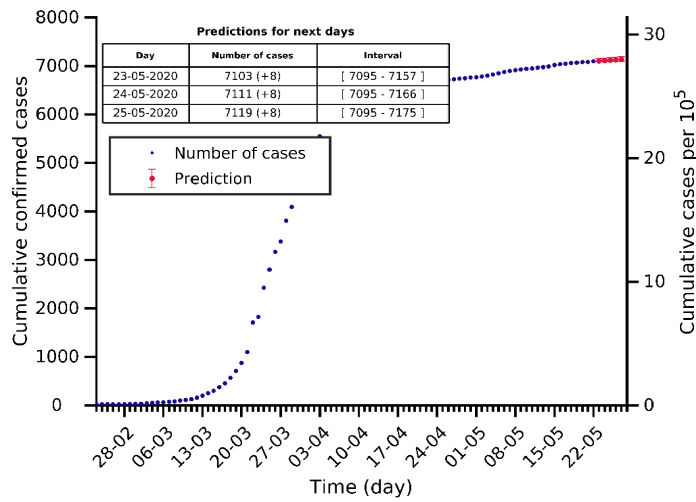
Argentina 22-05-2020. Population: 45.2M. Current cumulated incidence: 24/10⁵



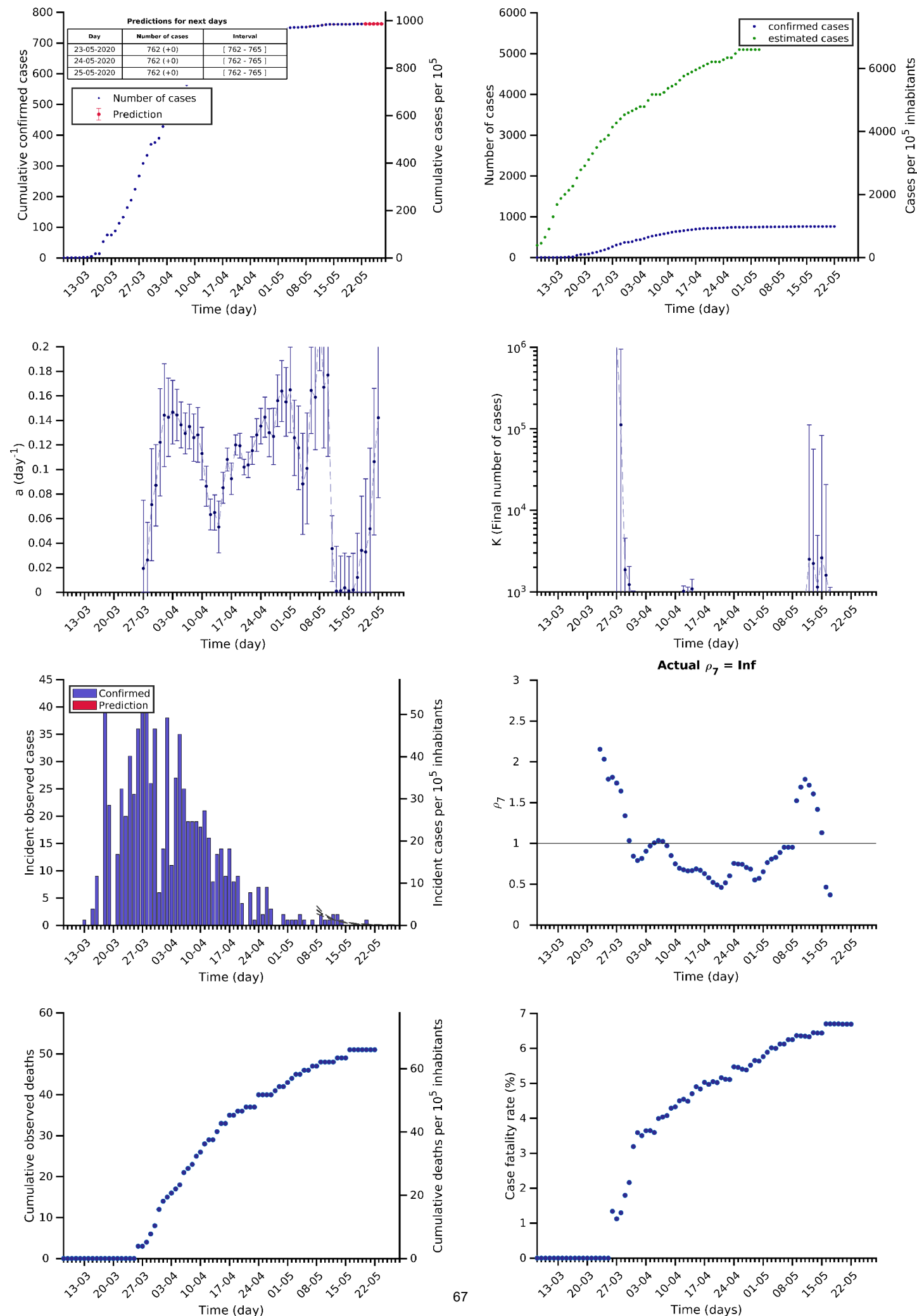
Malaysia 22-05-2020. Population: 32.4M. Current cumulated incidence: 22/10⁵



Australia 22-05-2020. Population: 25.5M. Current cumulated incidence: 28/10⁵



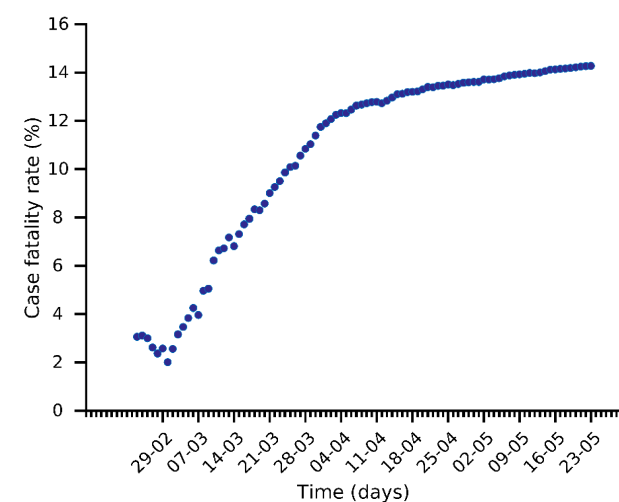
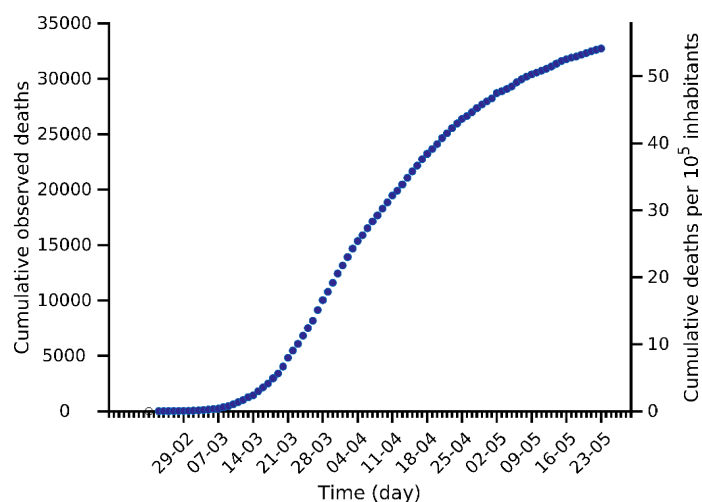
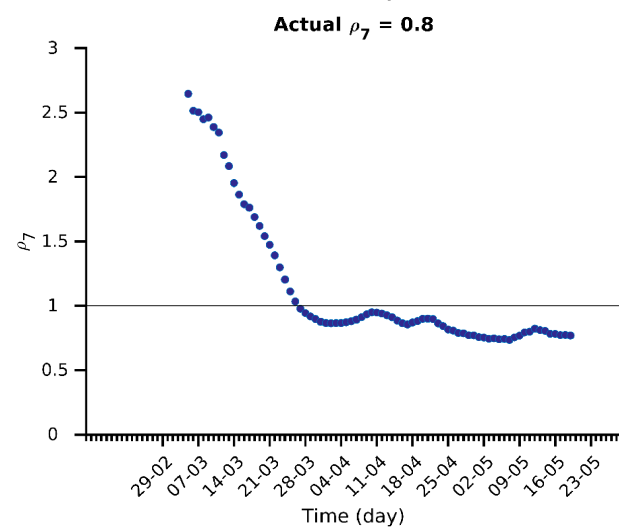
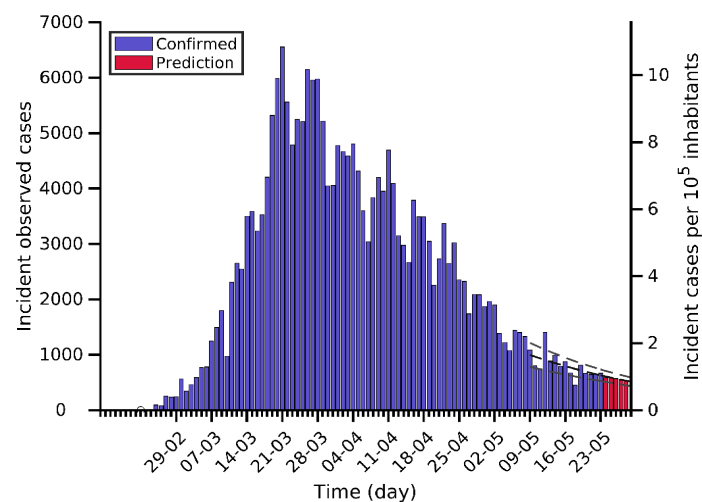
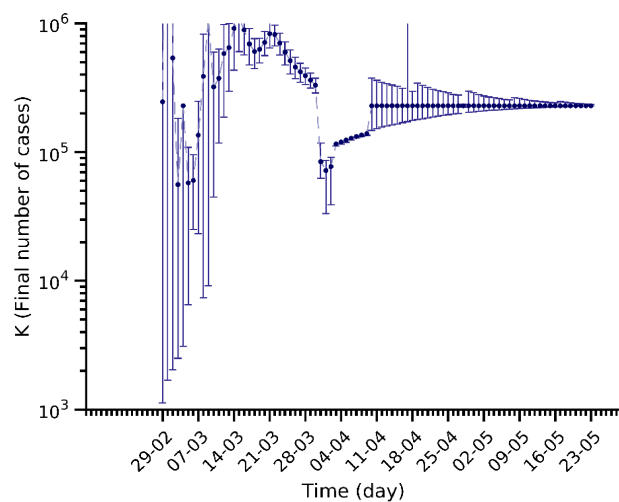
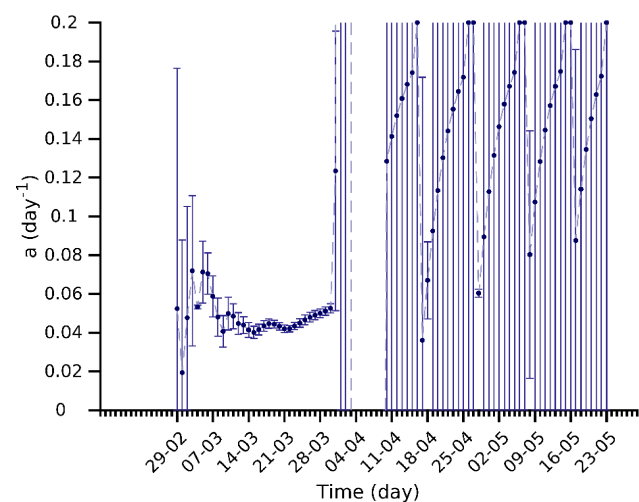
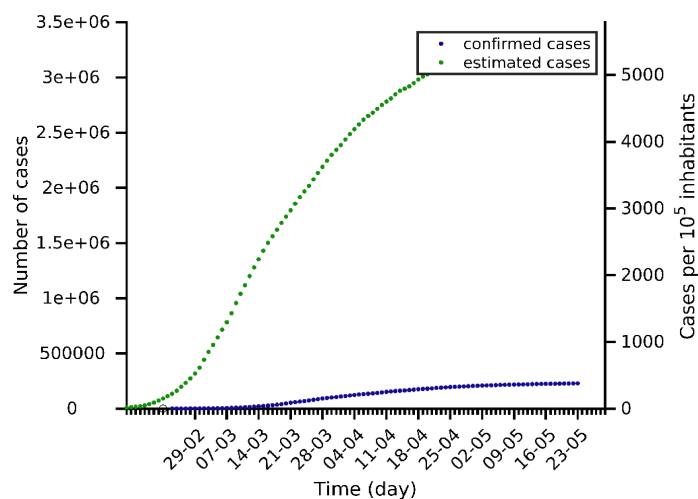
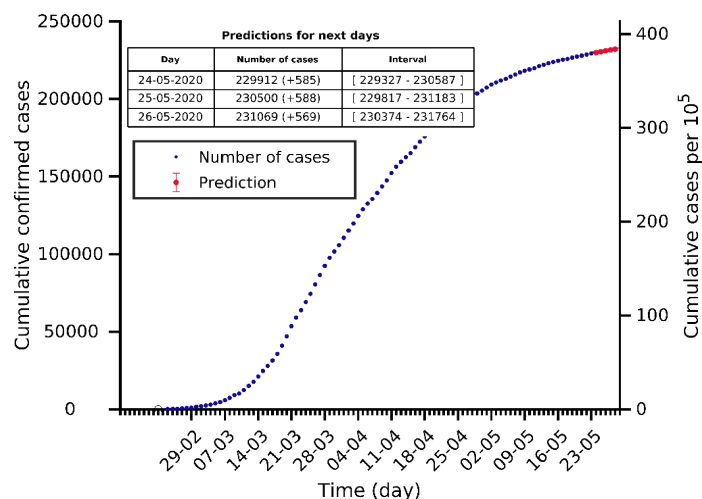
Andorra 22-05-2020. Population: 0.1M. Current cumulated incidence: 986/10⁵



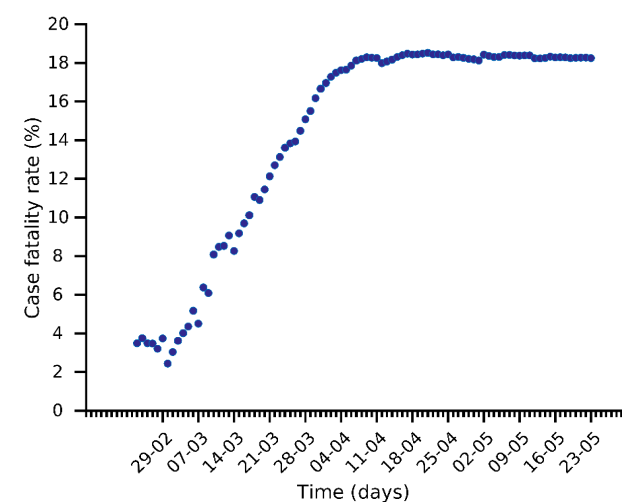
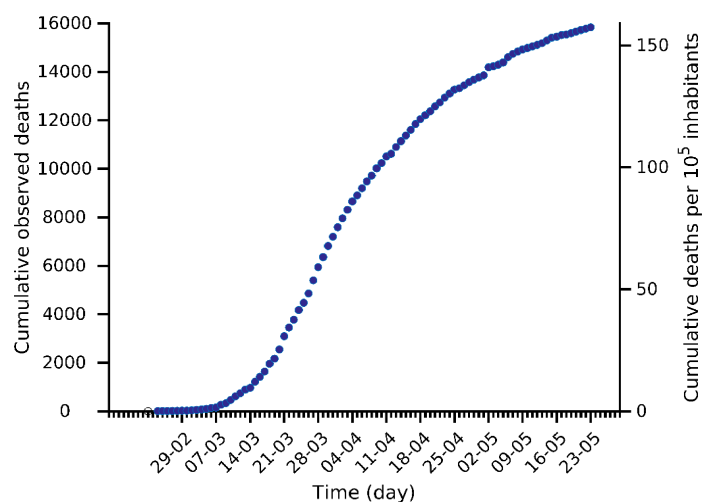
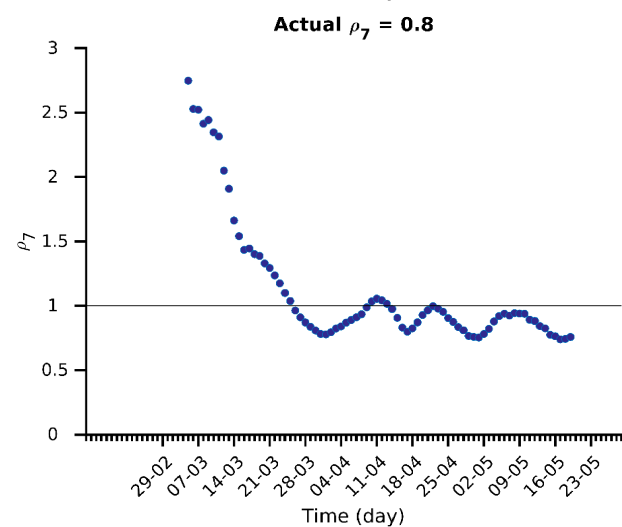
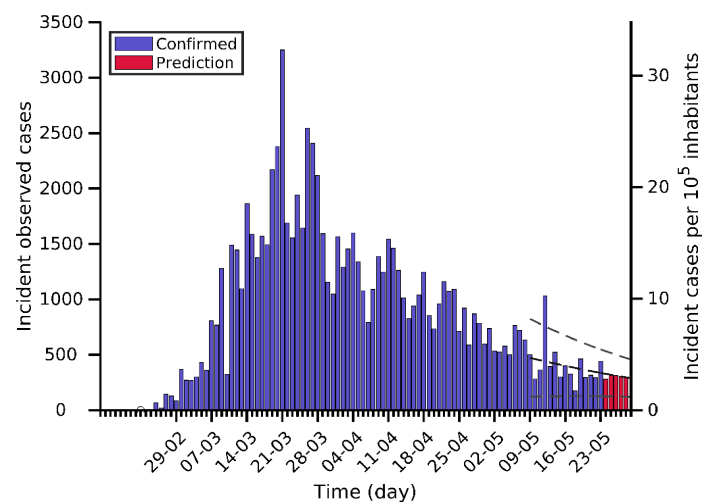
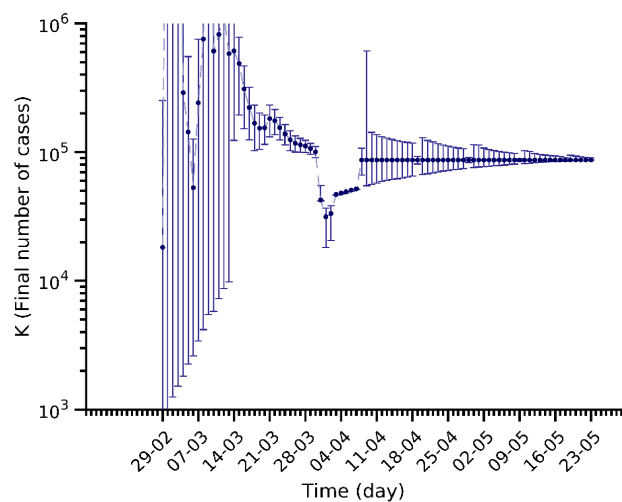
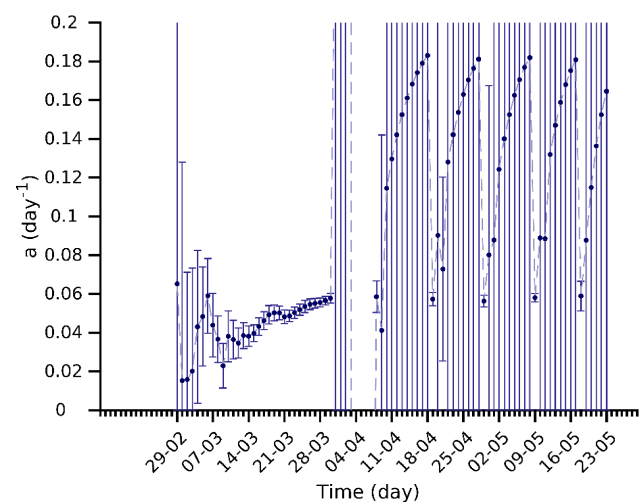
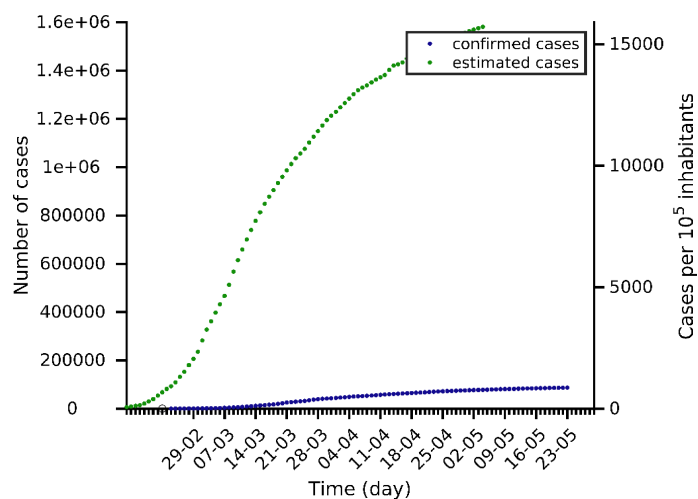
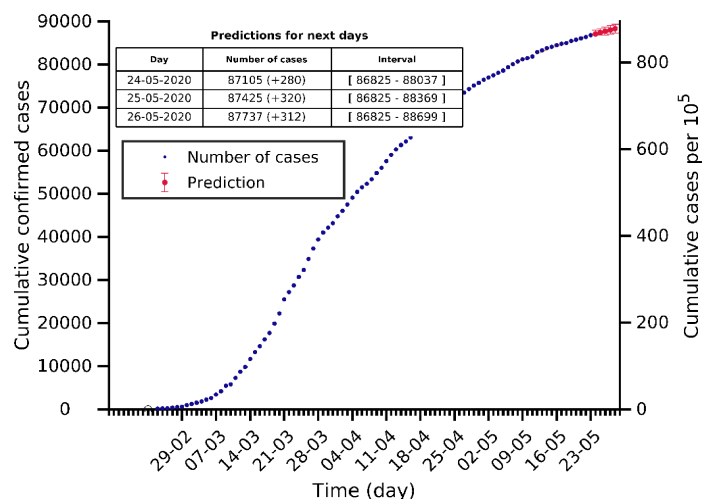
(3) Analysis and prediction of COVID-19 for Italy and its regions

Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>

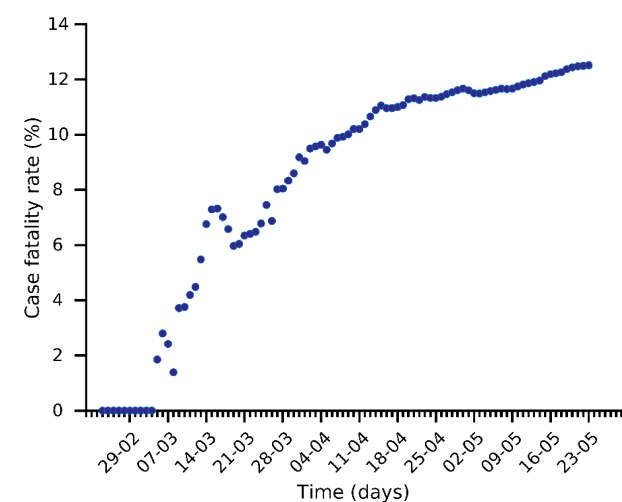
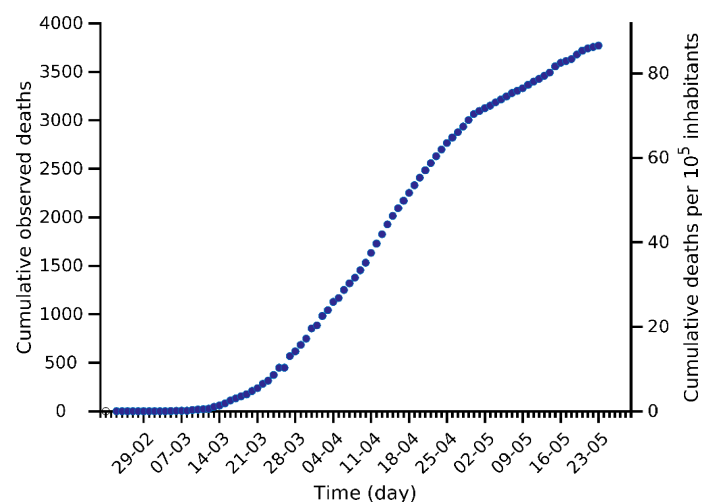
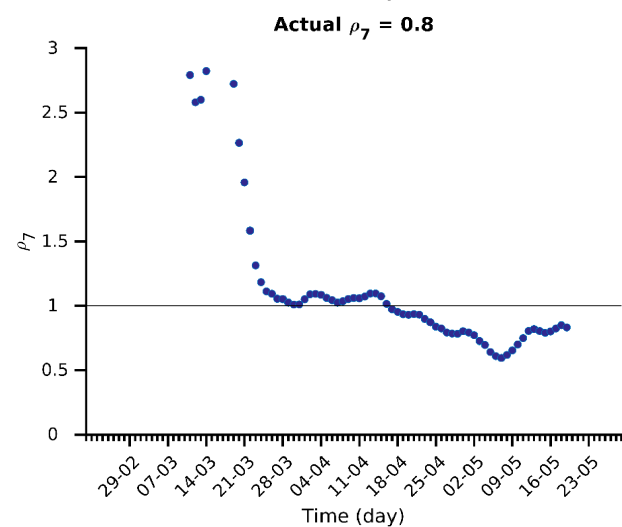
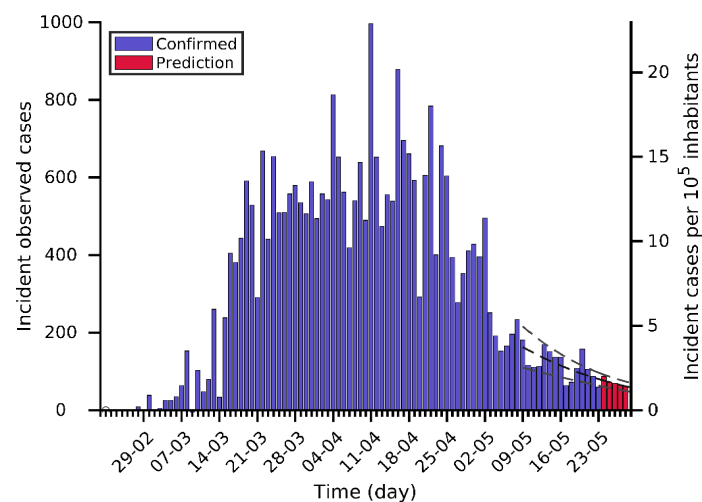
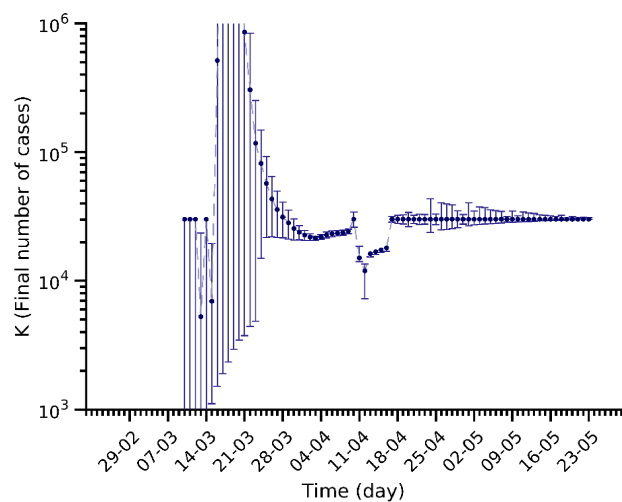
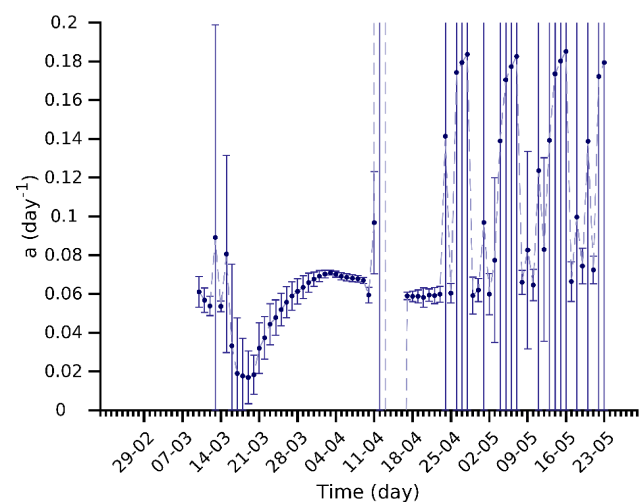
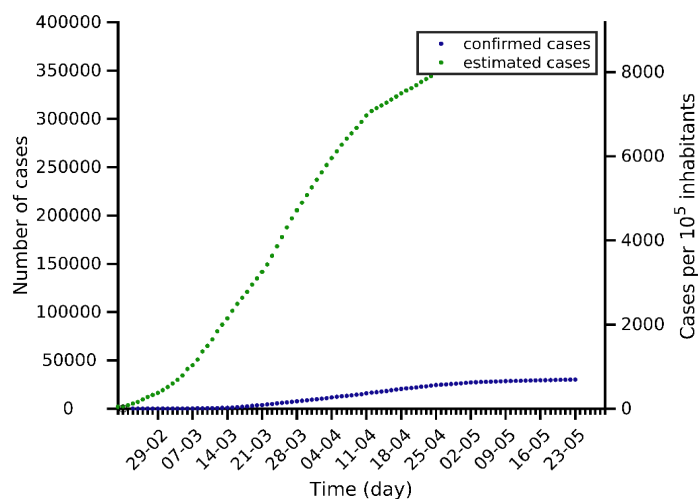
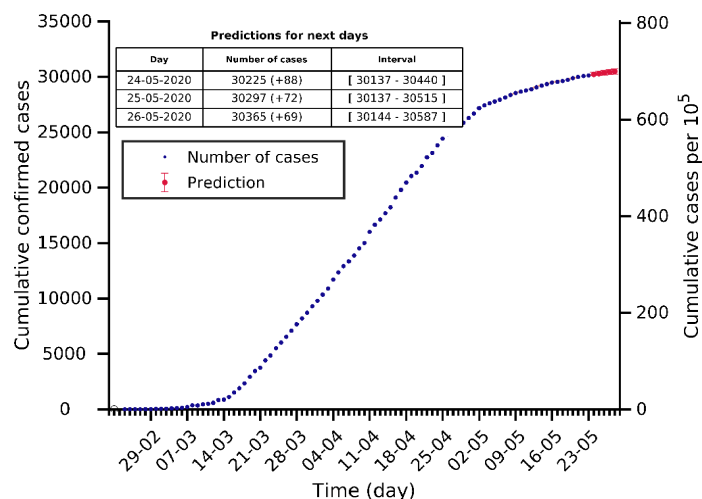
Italy 23-05-2020. Population: 60.5M. Current cumulated incidence: 379/10⁵



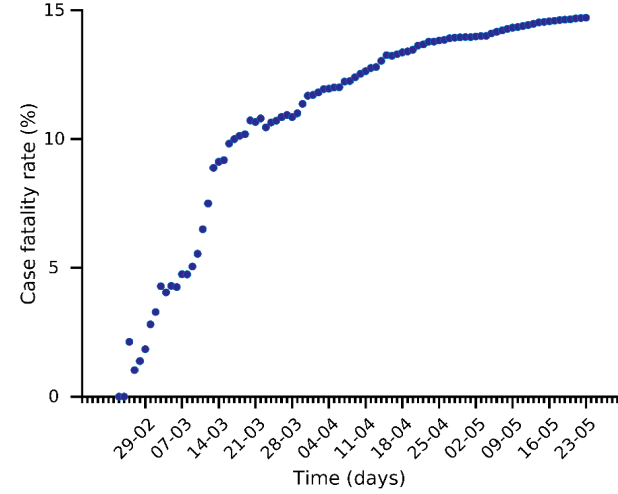
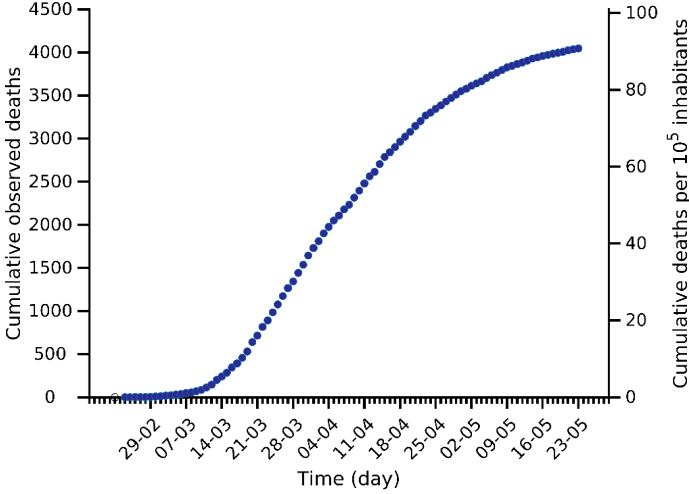
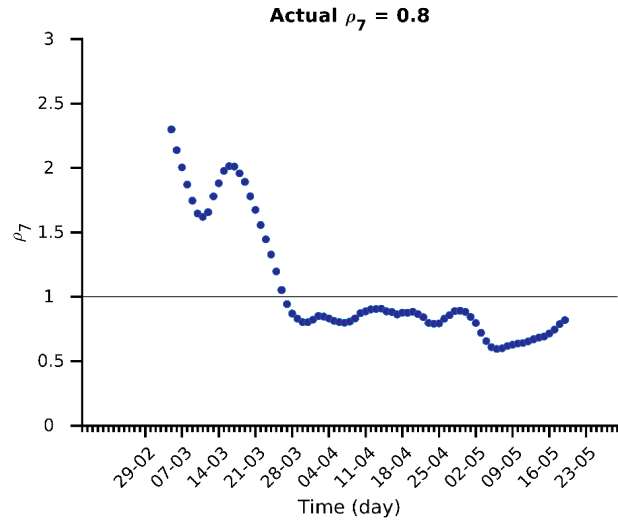
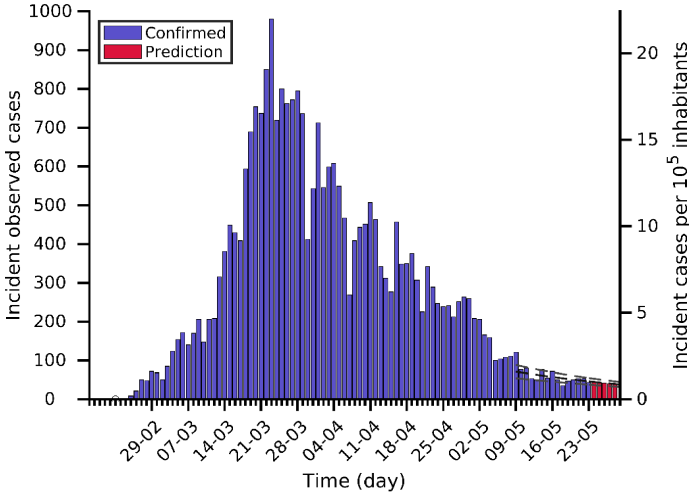
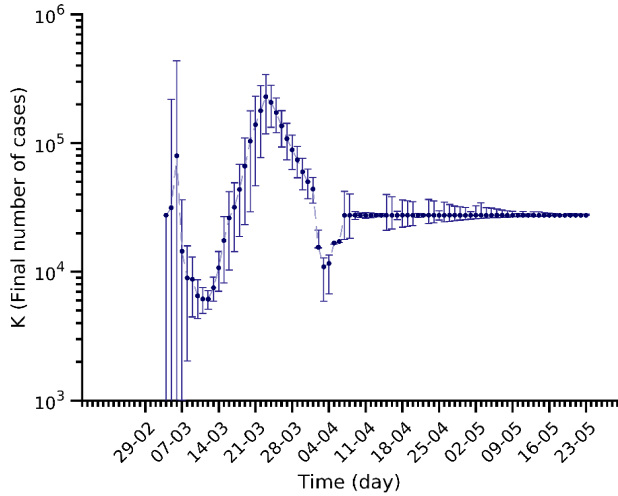
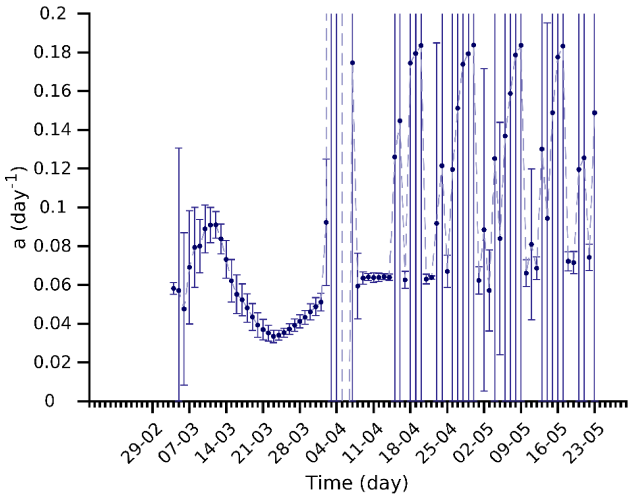
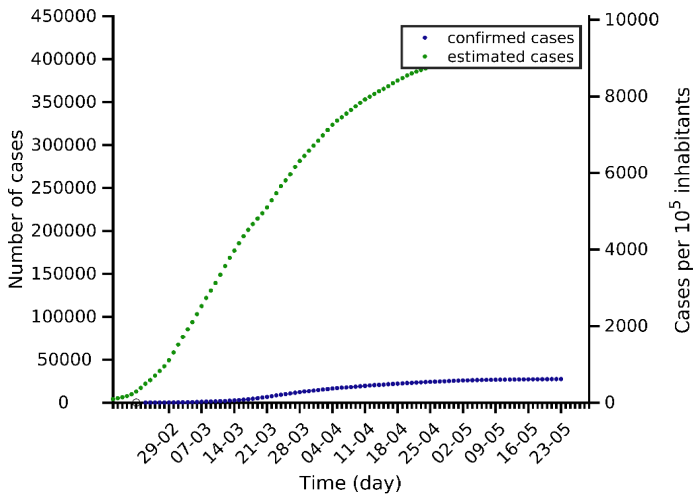
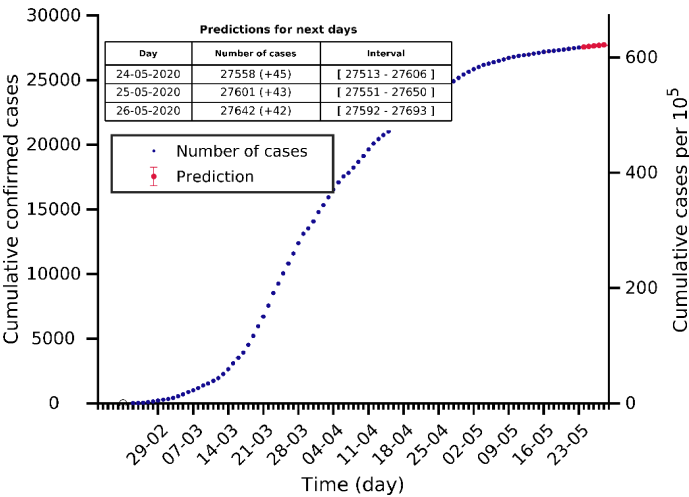
Lombardia 23-05-2020. Population: 10.1M. Current cumulated incidence: 863/10⁵



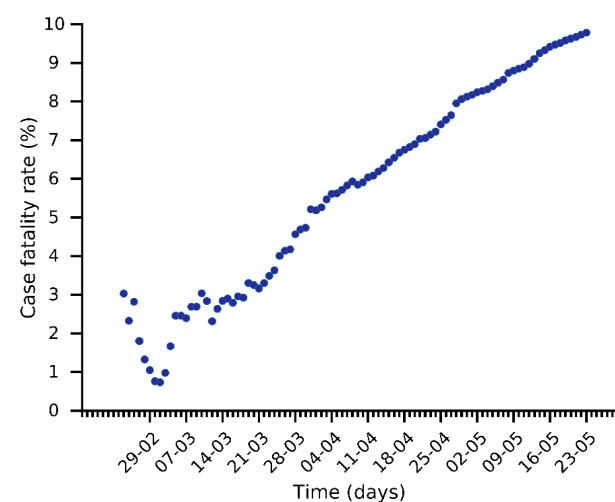
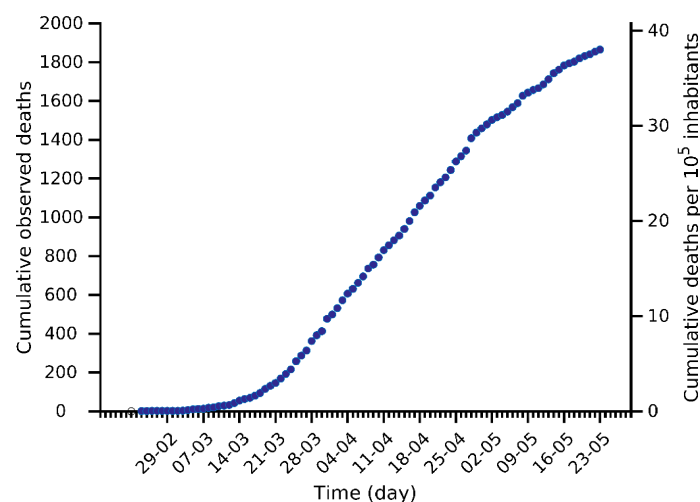
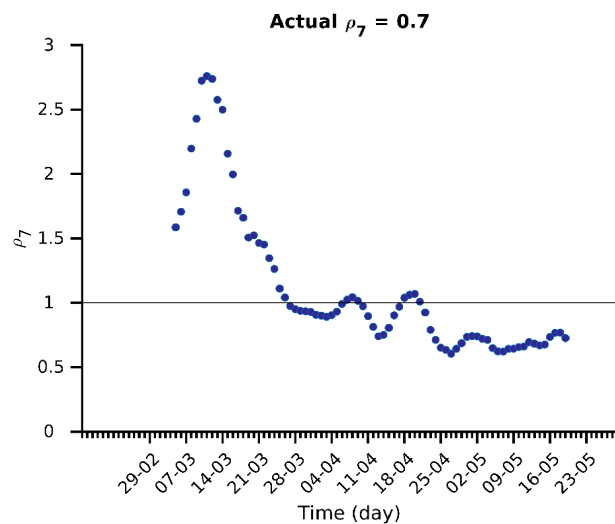
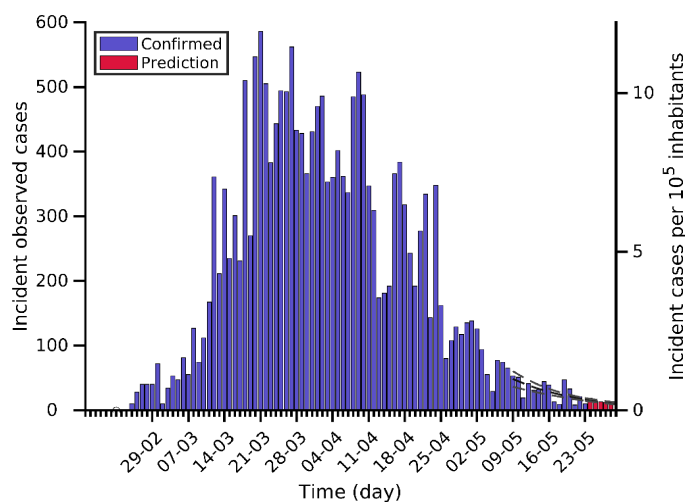
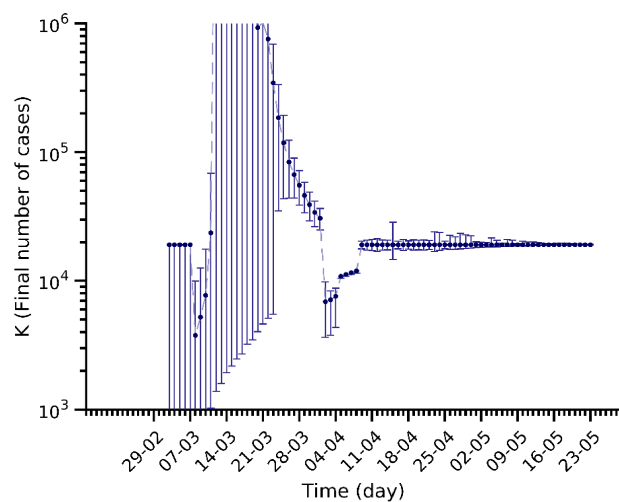
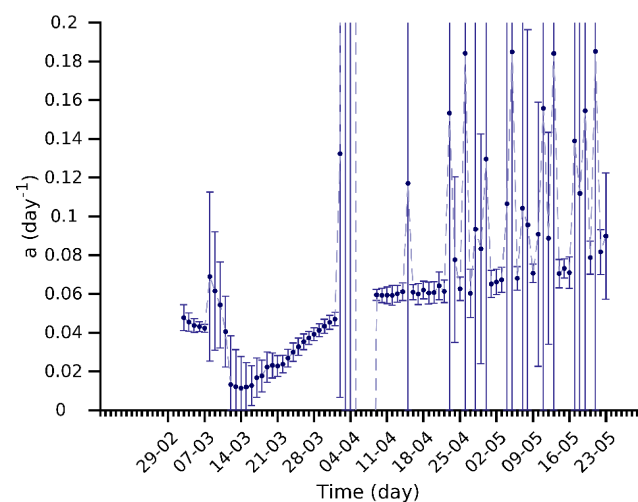
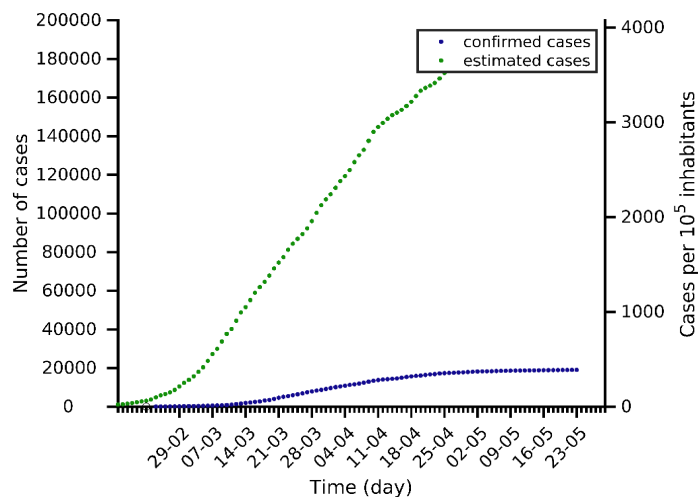
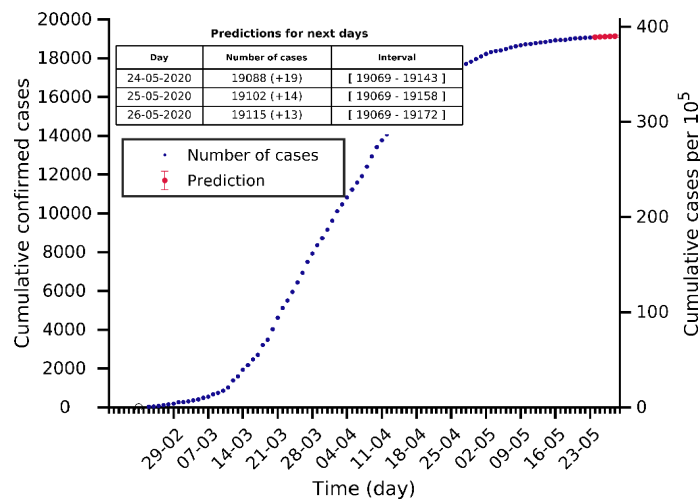
Piemonte 23-05-2020. Population: 4.4M. Current cumulated incidence: 692/10⁵



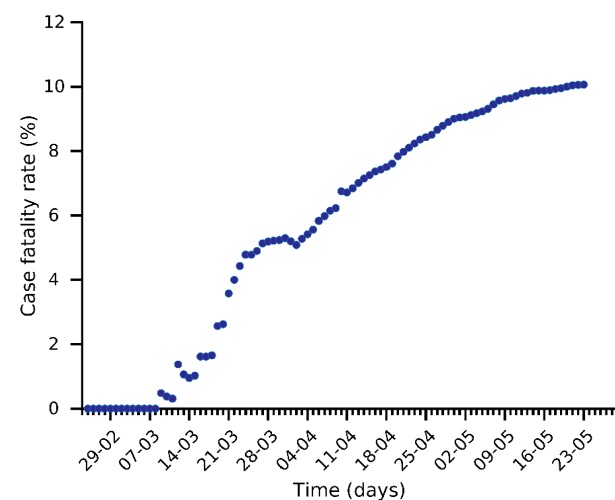
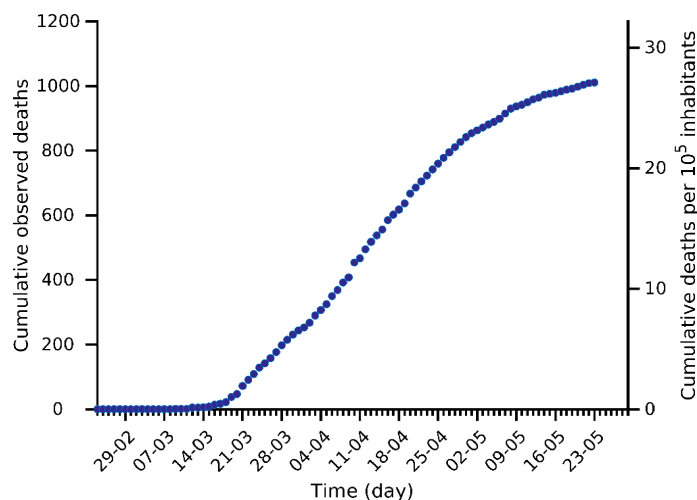
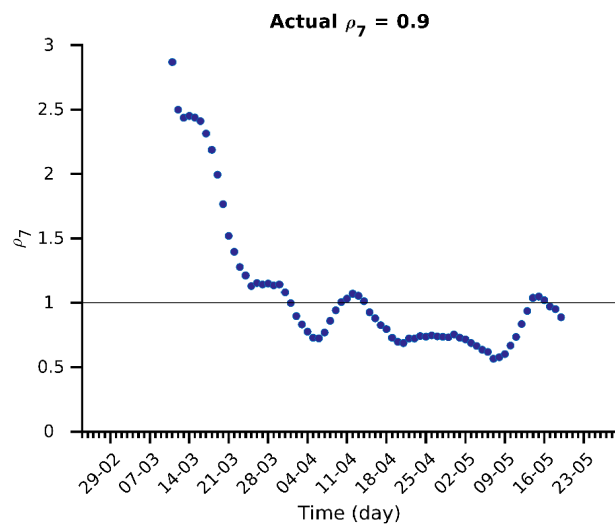
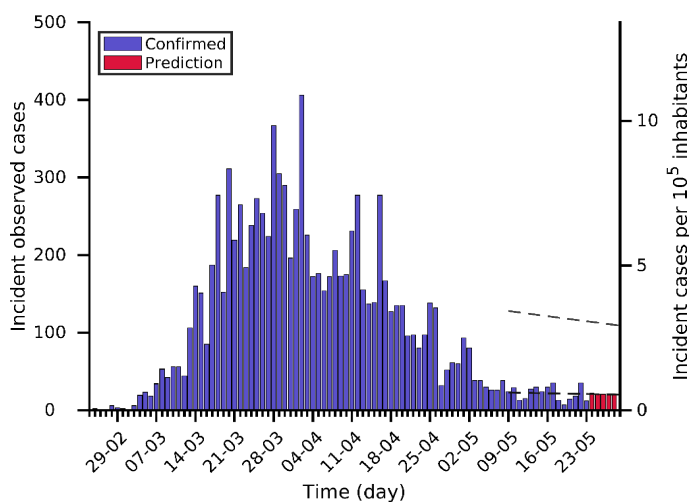
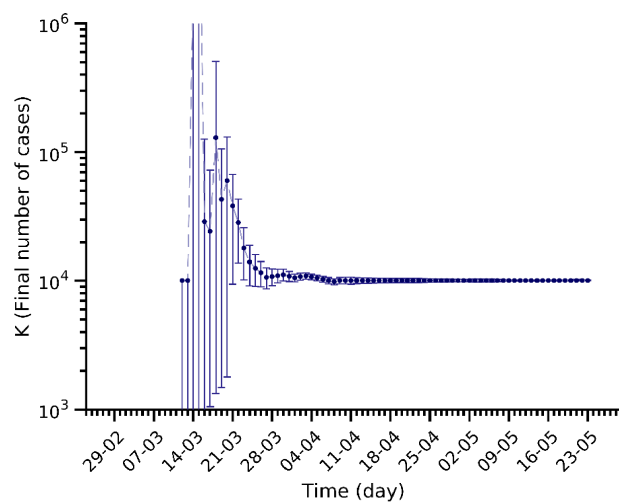
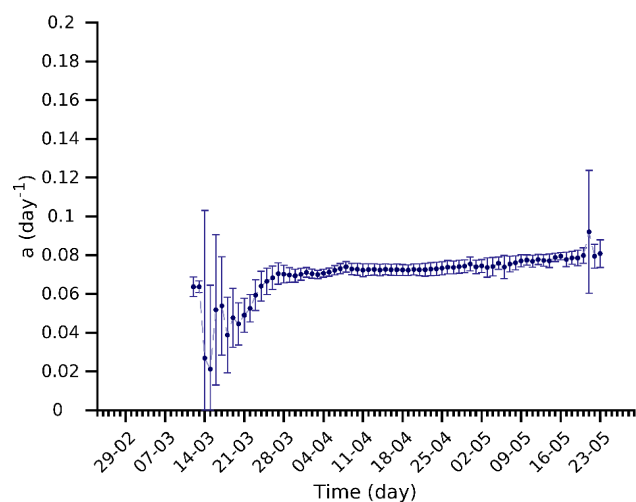
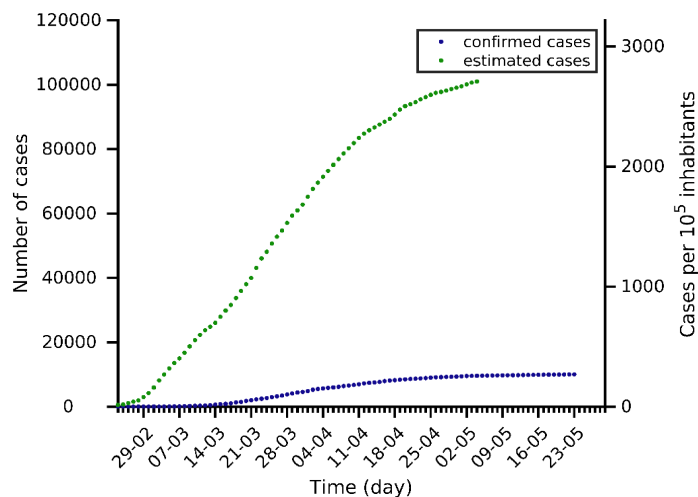
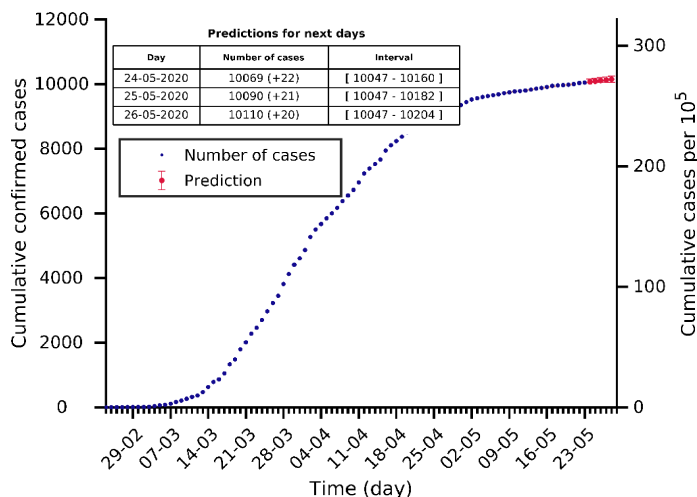
Emilia Romagna 23-05-2020. Population: 4.5M. Current cumulated incidence: 617/100000



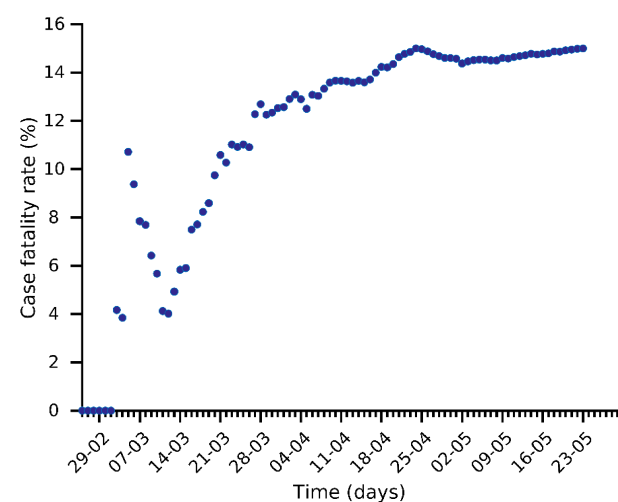
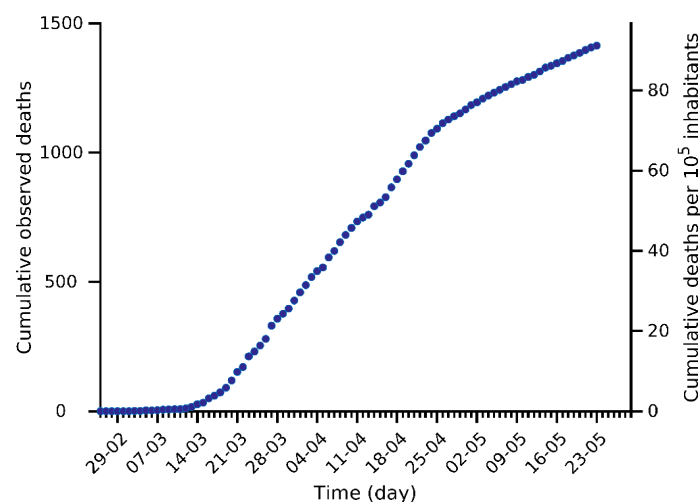
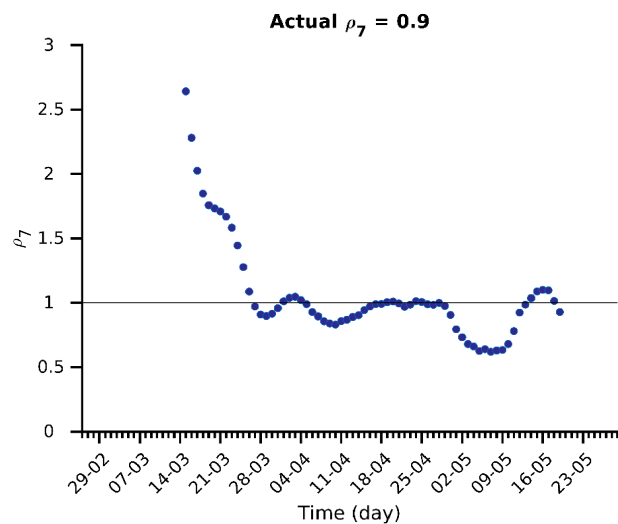
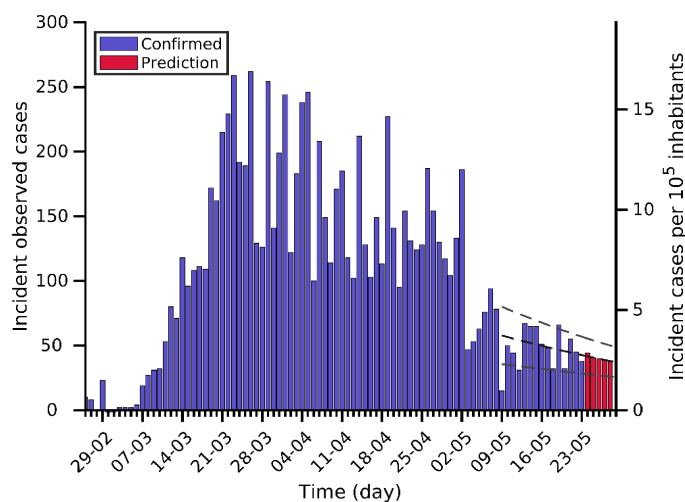
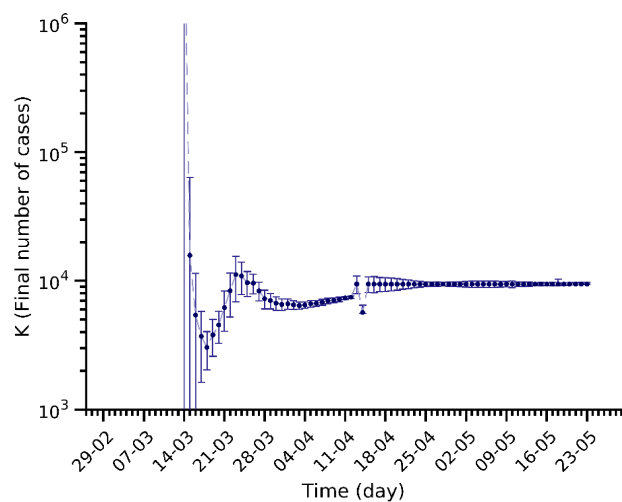
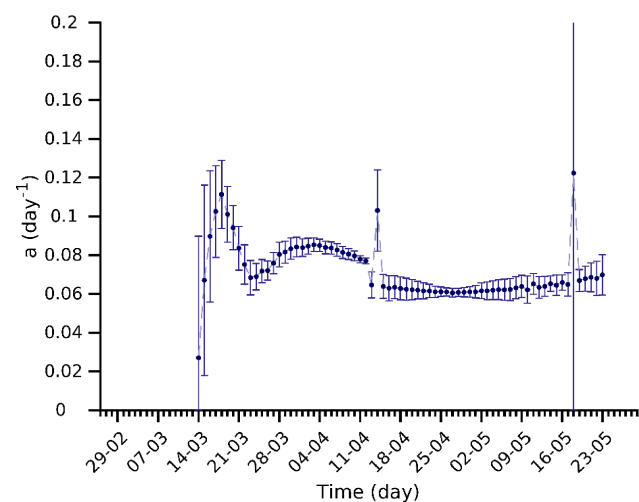
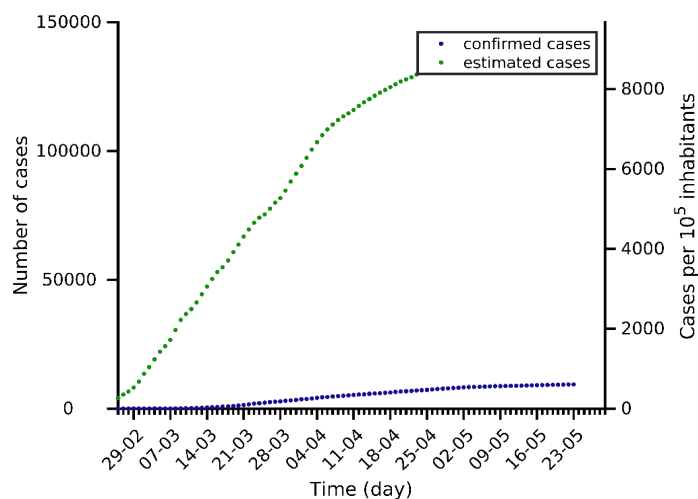
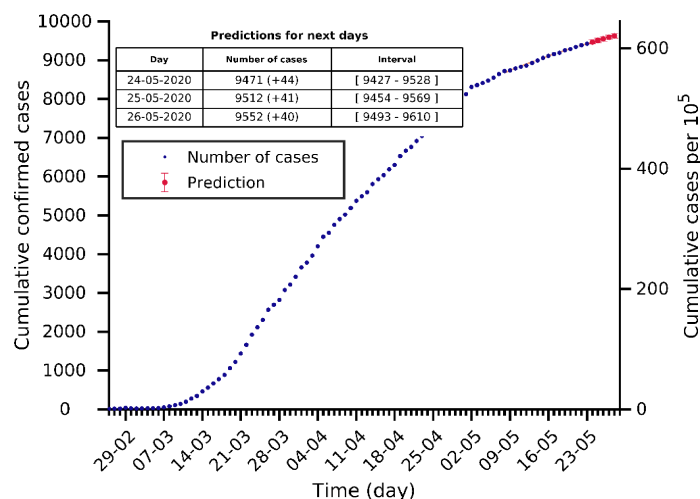
Veneto 23-05-2020. Population: 4.9M. Current cumulated incidence: 389/10⁵



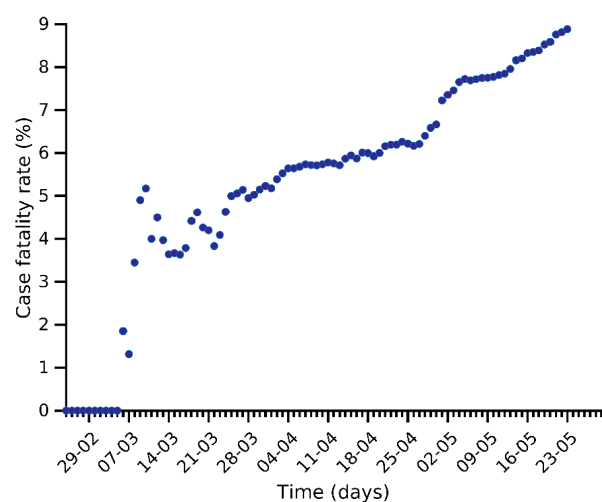
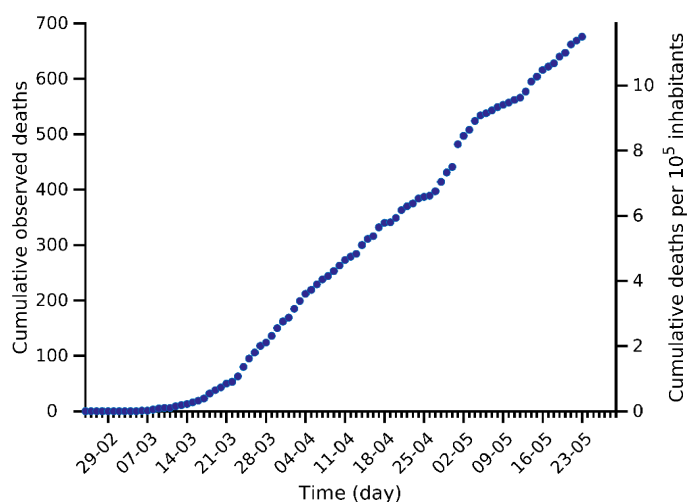
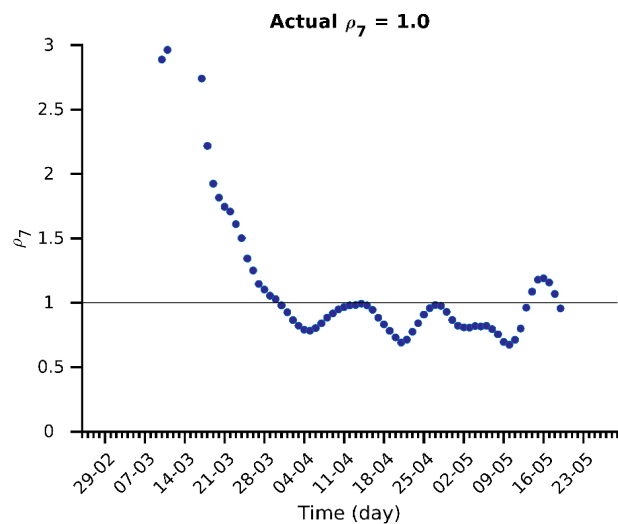
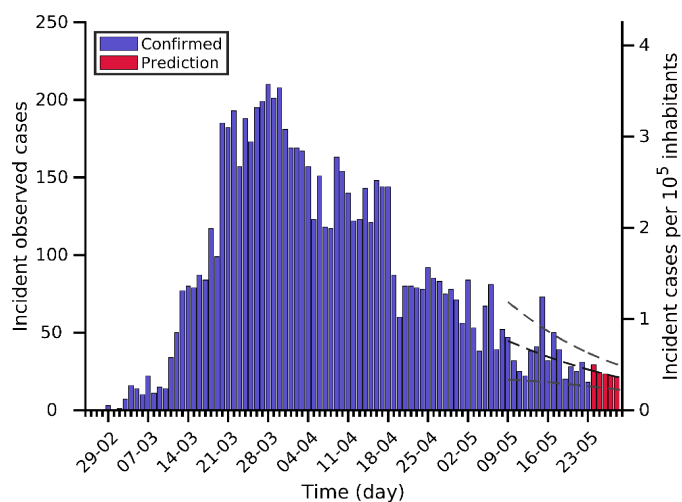
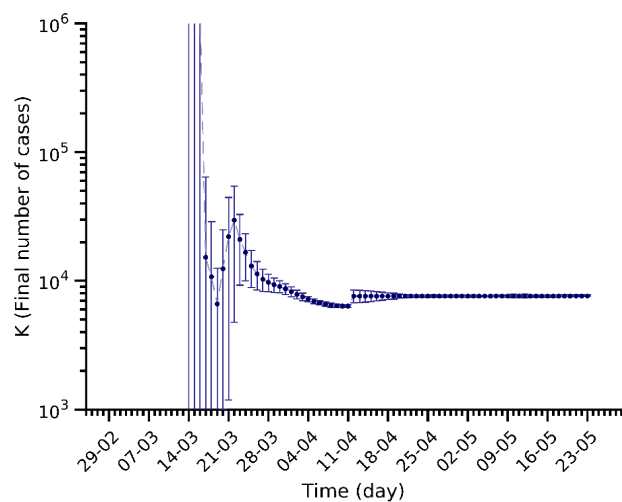
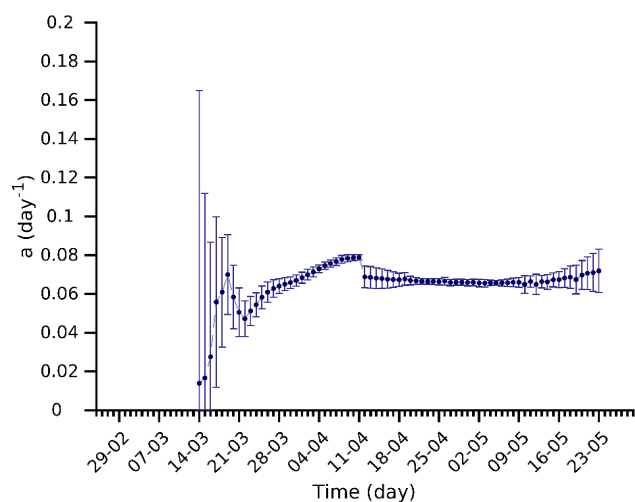
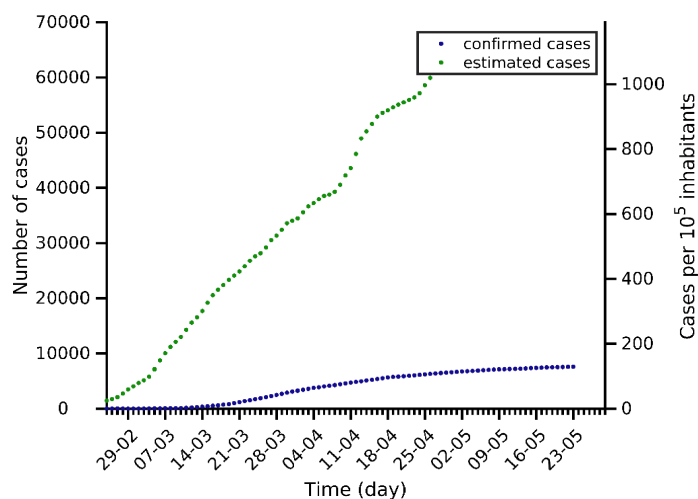
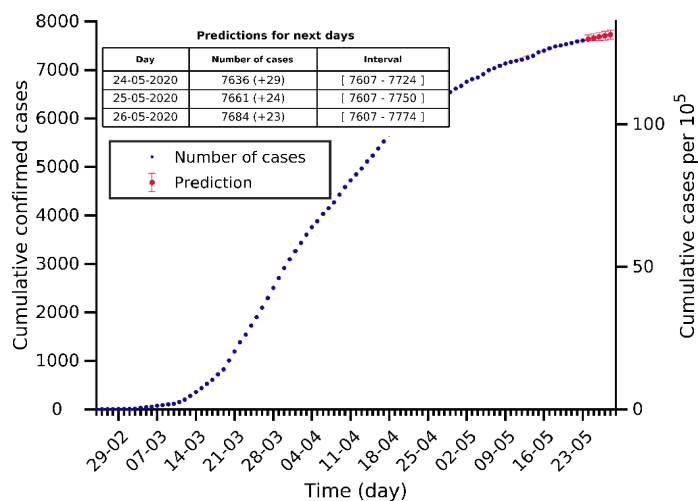
Toscana 23-05-2020. Population: 3.7M. Current cumulated incidence: 269/10⁵



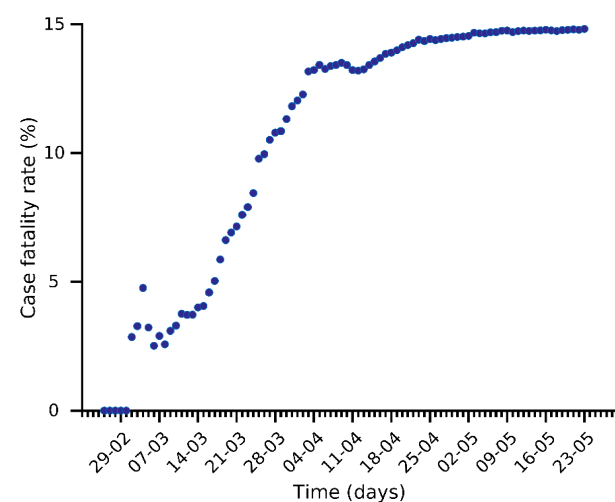
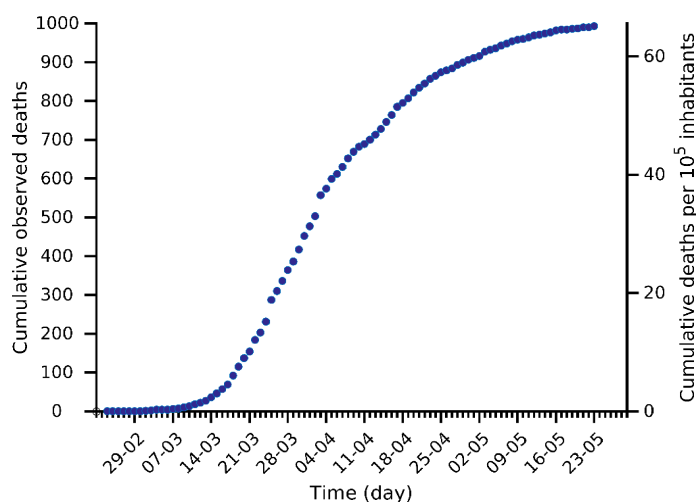
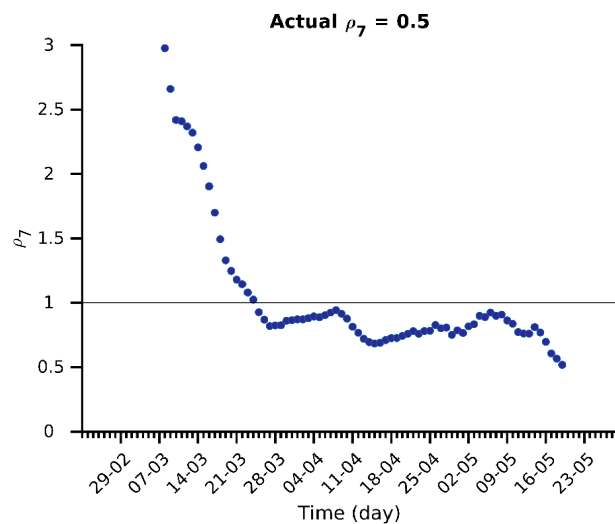
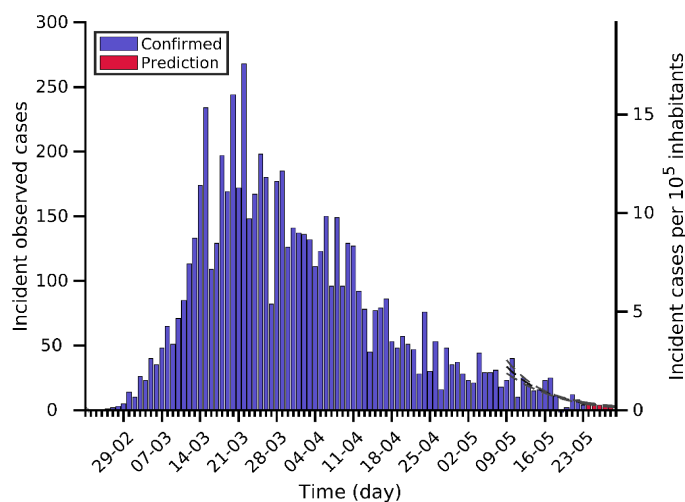
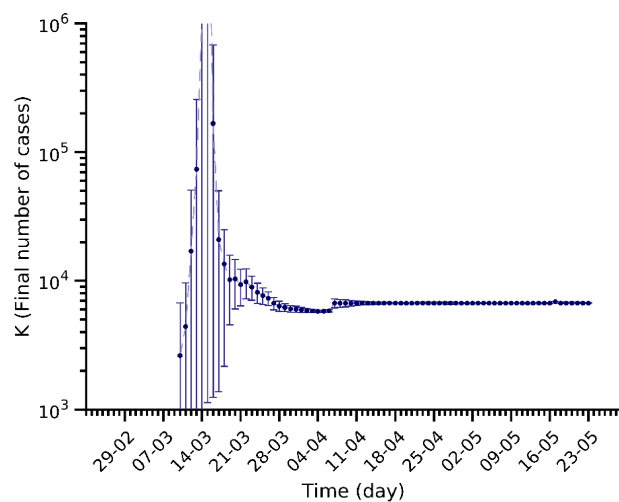
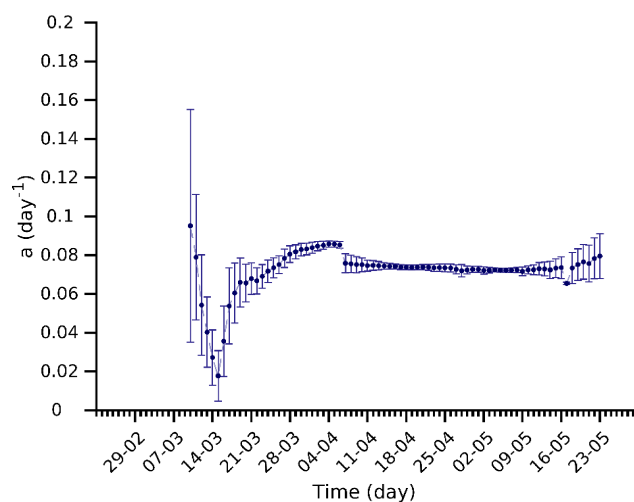
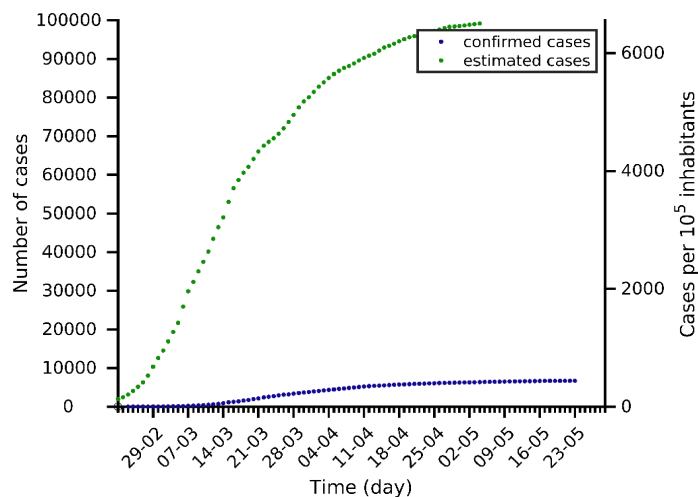
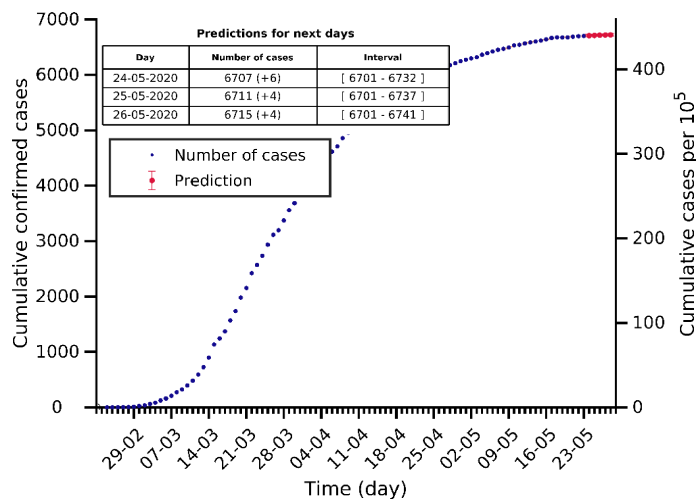
Liguria 23-05-2020. Population: 1.6M. Current cumulated incidence: 608/10⁵



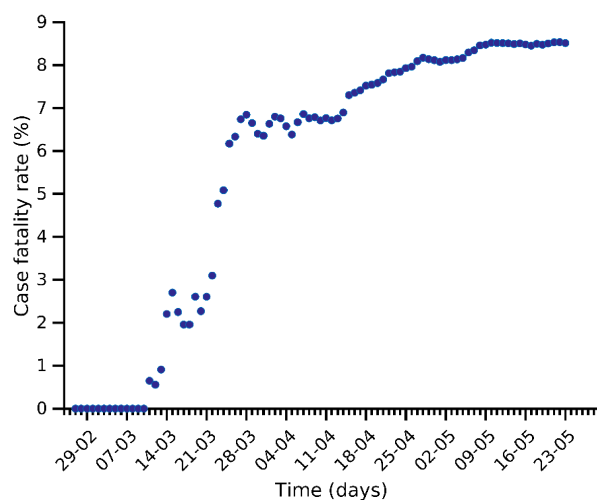
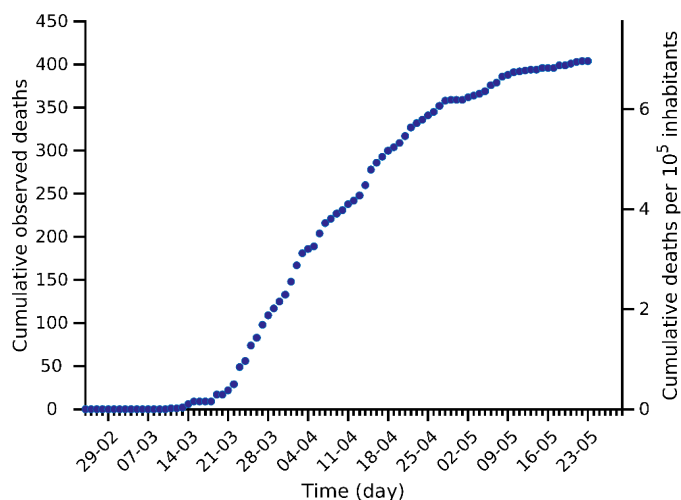
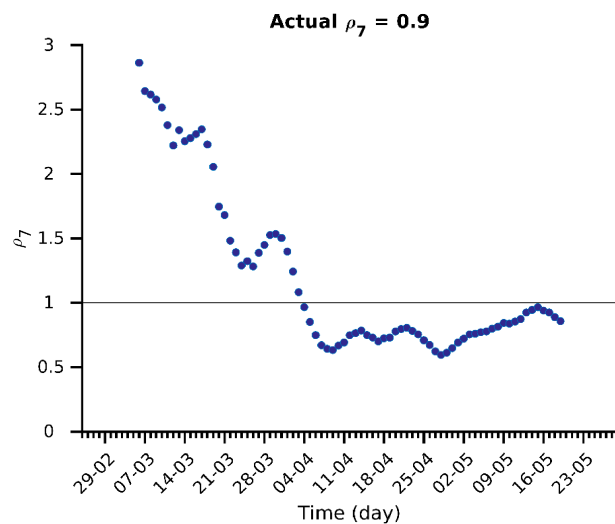
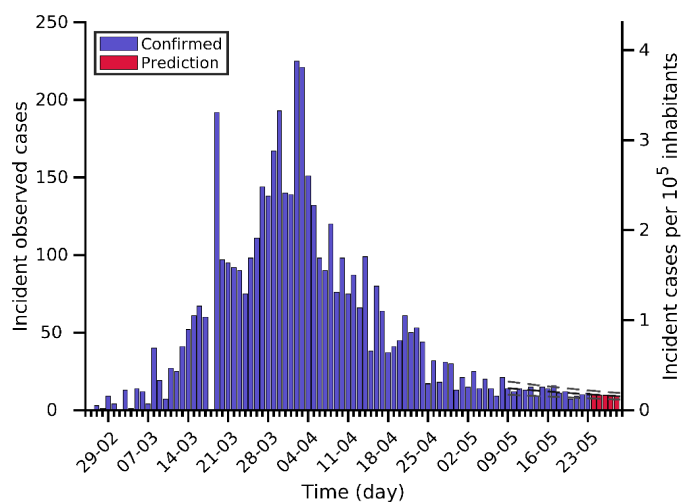
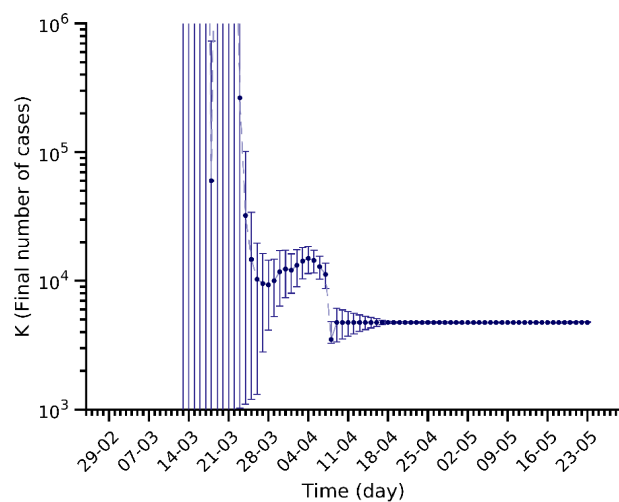
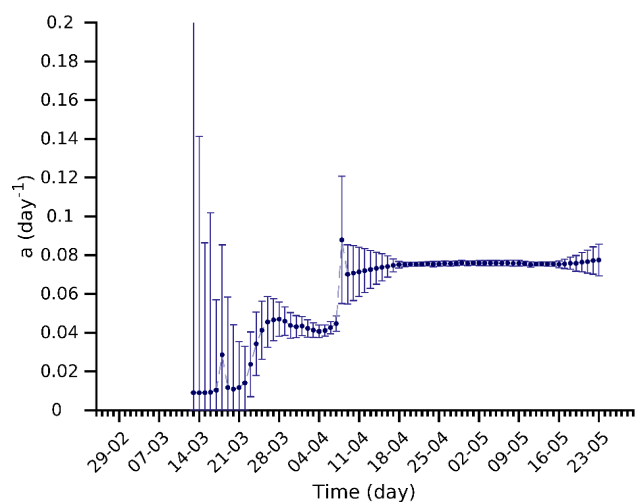
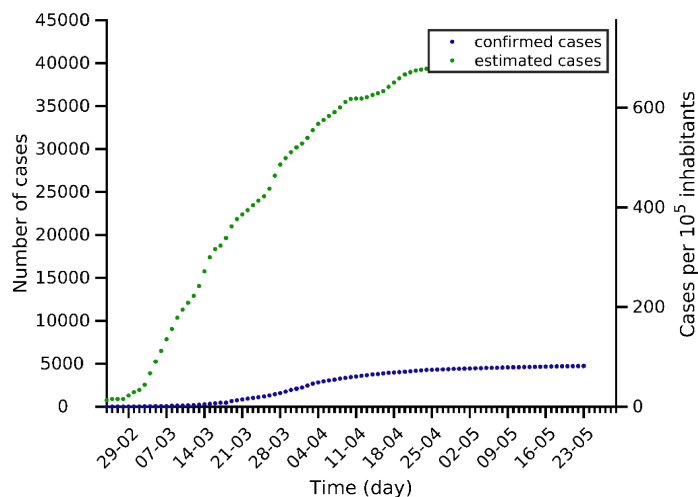
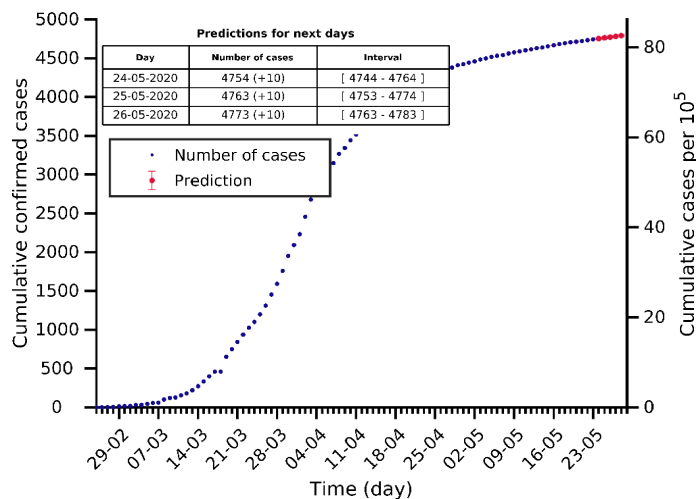
Lazio 23-05-2020. Population: 5.9M. Current cumulated incidence: 129/10⁵



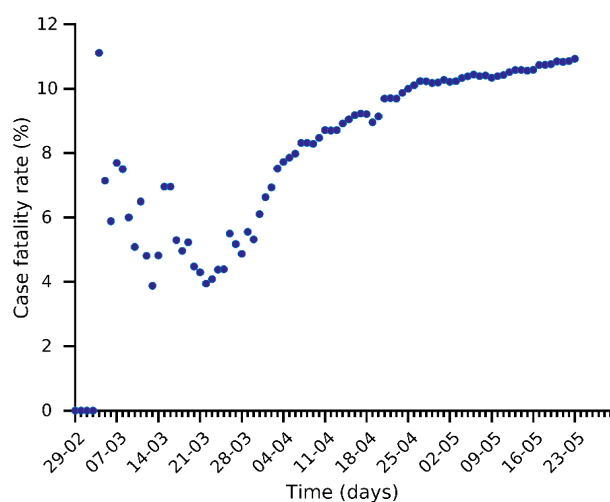
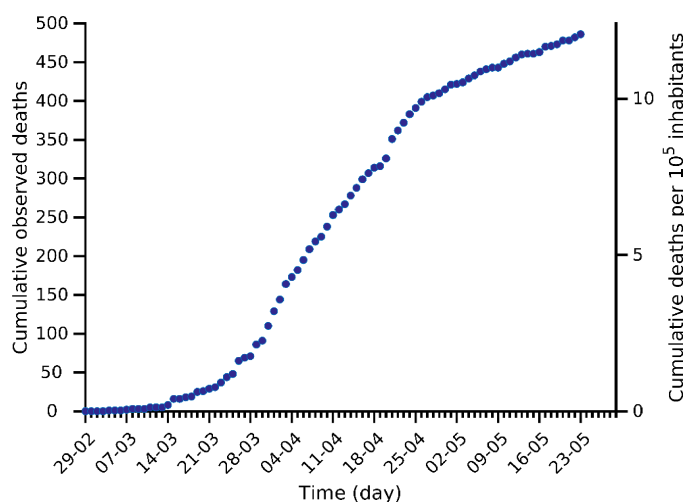
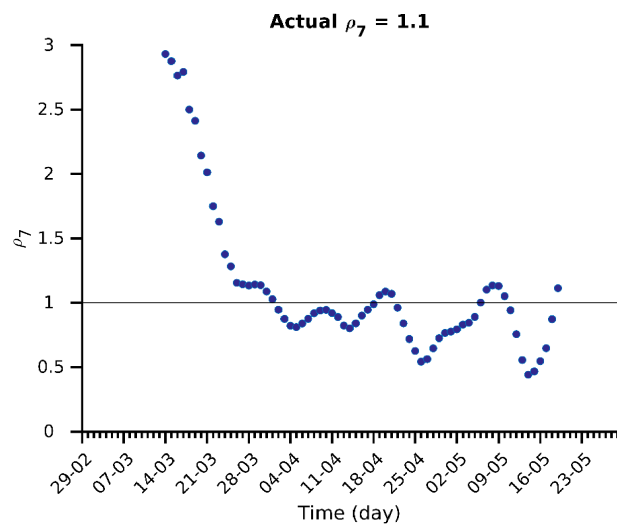
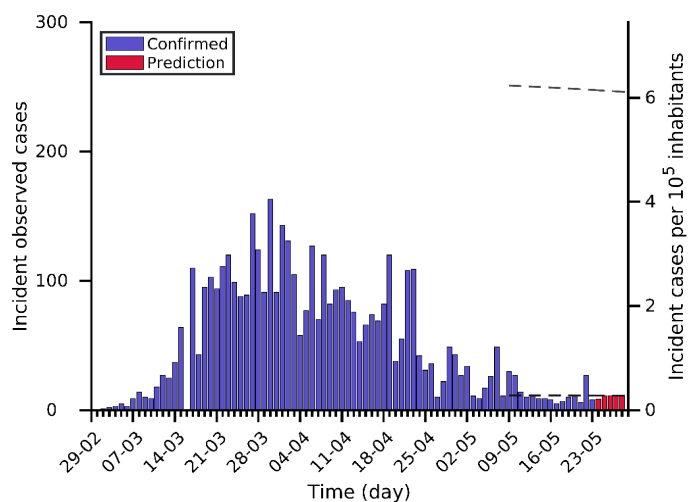
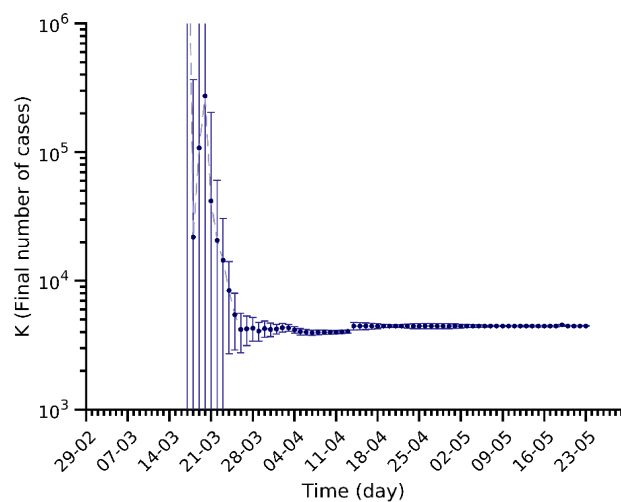
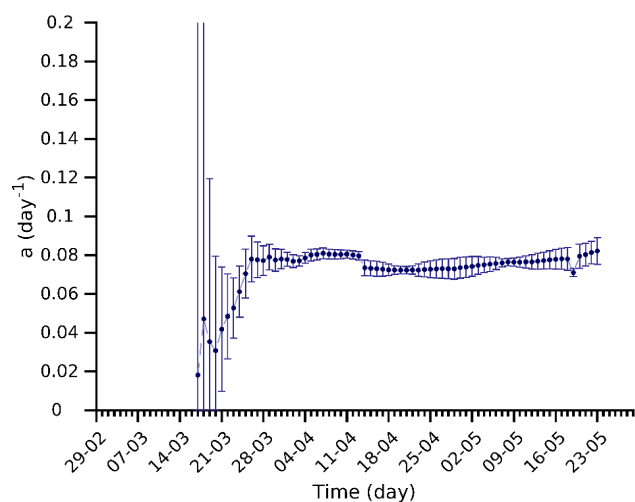
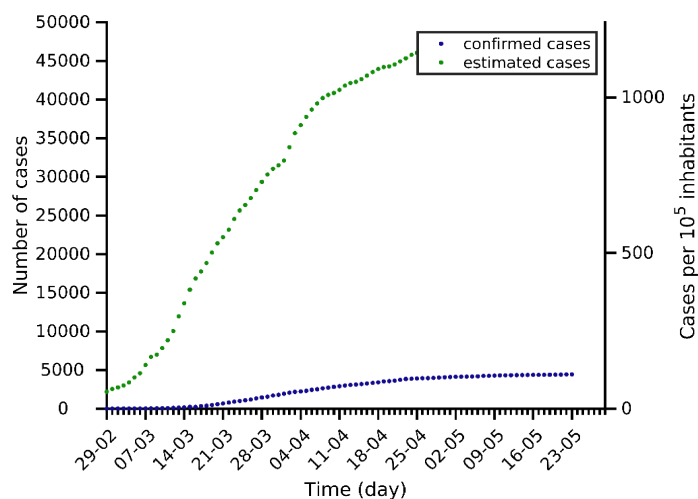
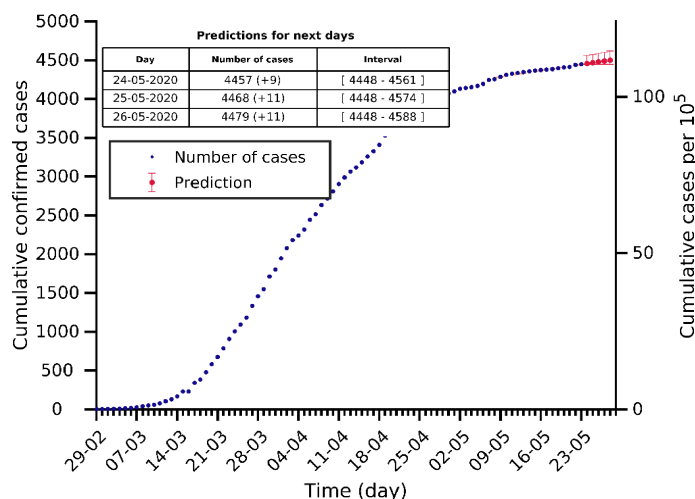
Marche 23-05-2020. Population: 1.5M. Current cumulated incidence: 439/10⁵



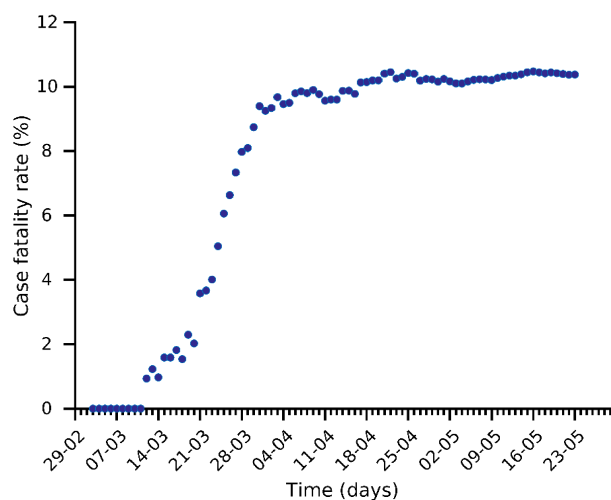
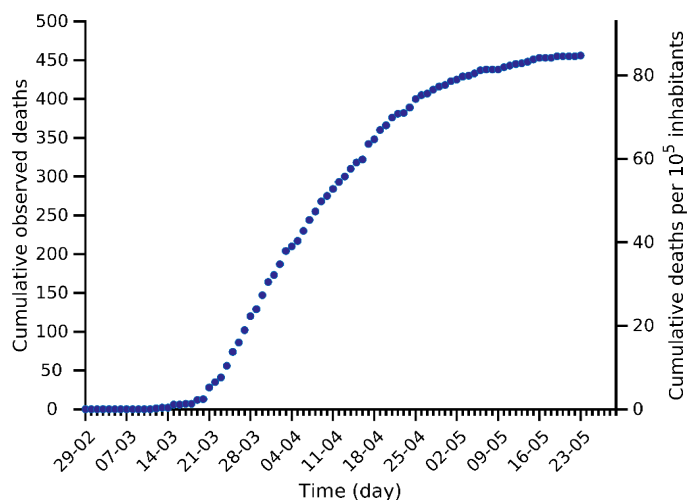
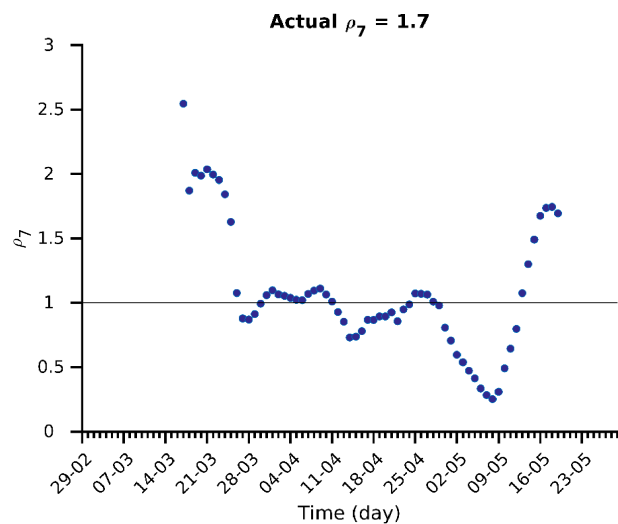
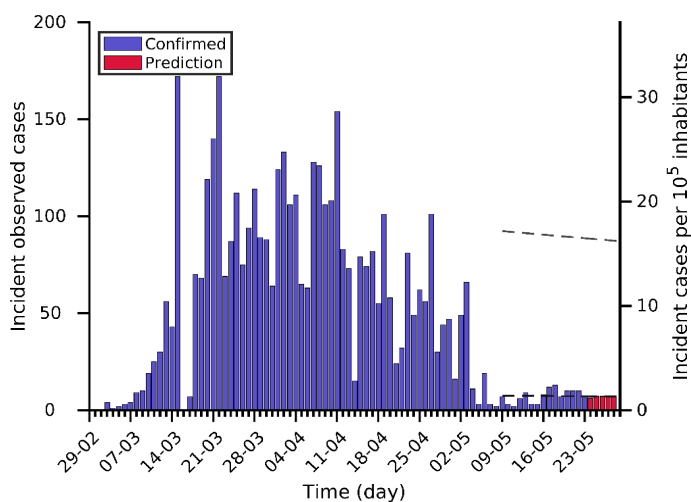
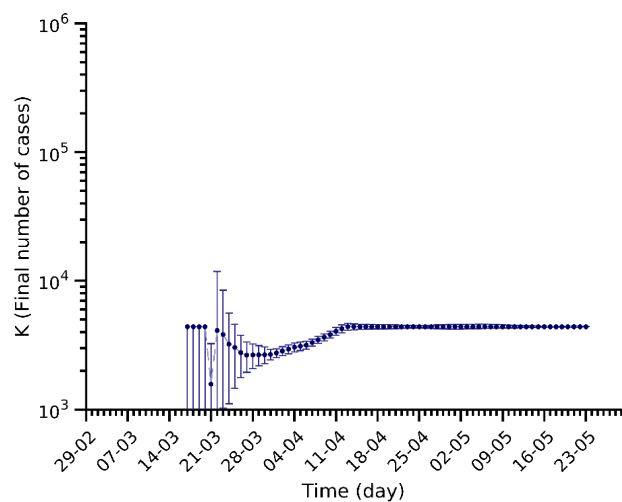
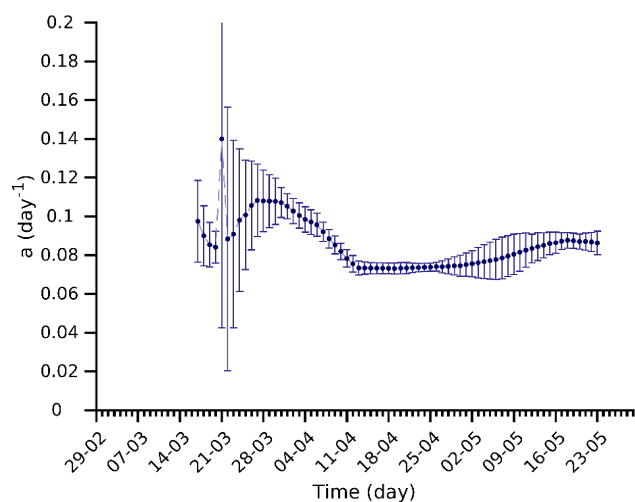
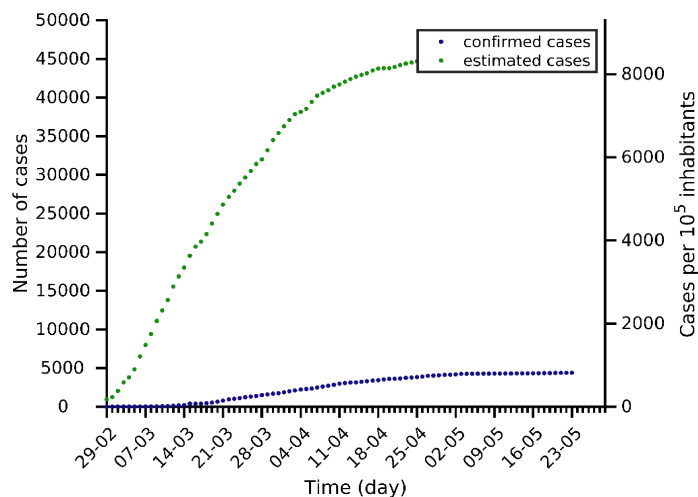
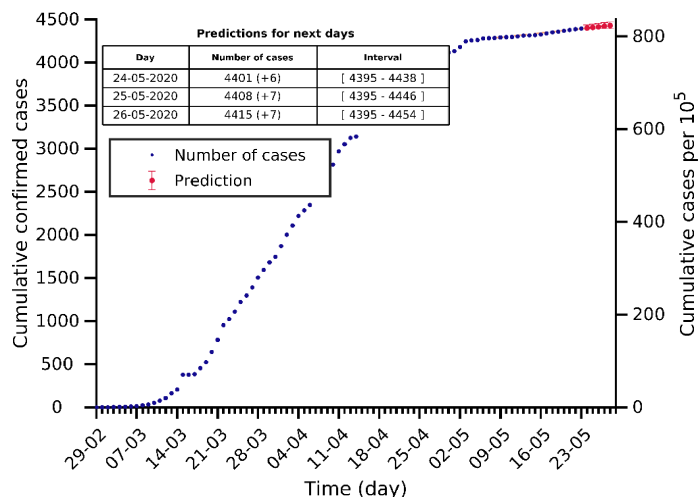
Campania 23-05-2020. Population: 5.8M. Current cumulated incidence: 82/10⁵



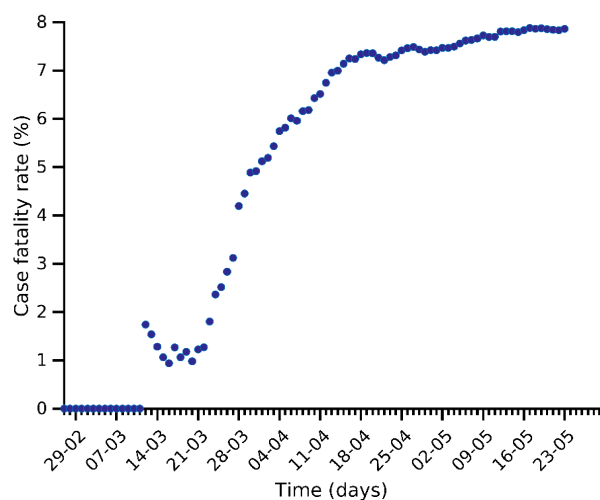
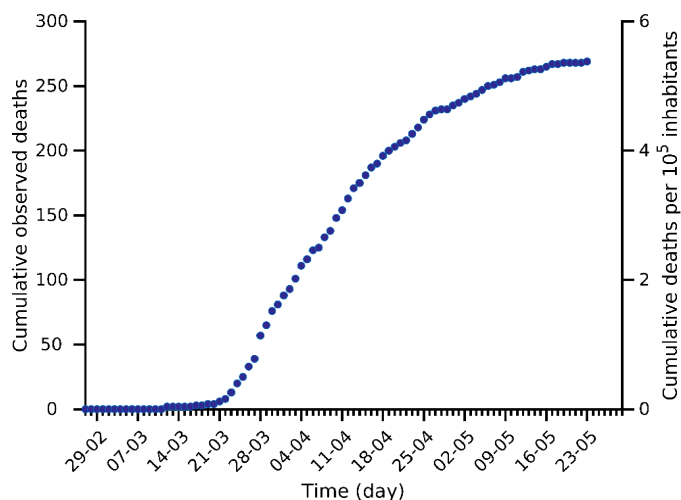
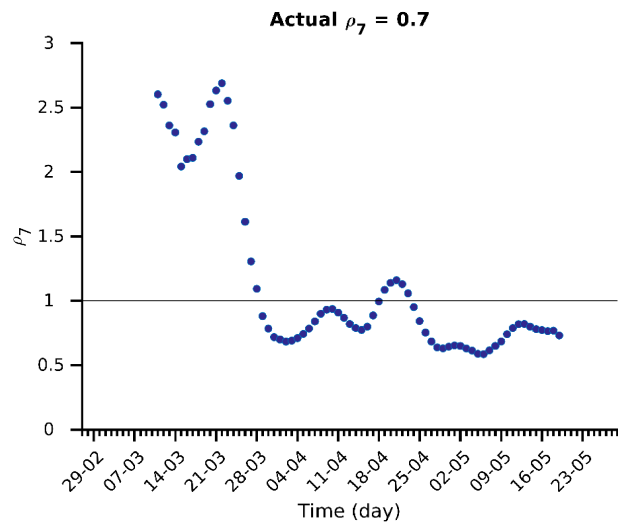
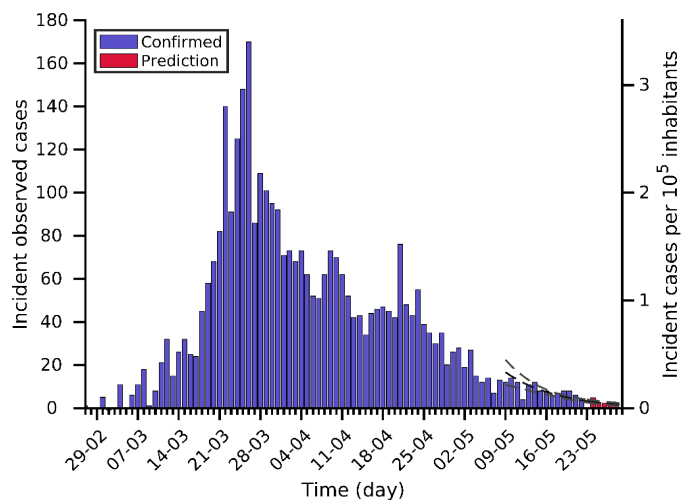
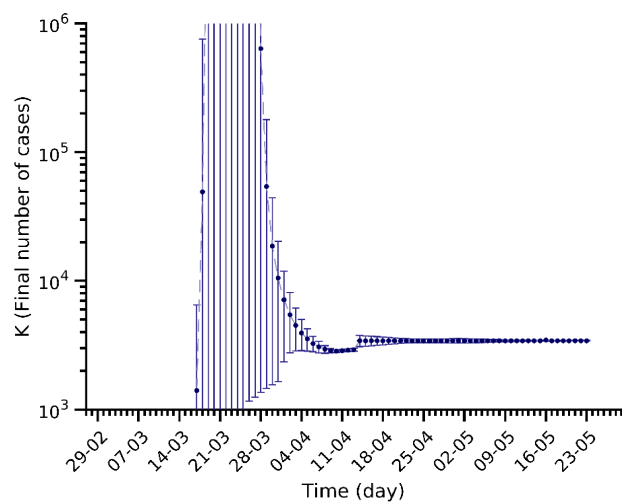
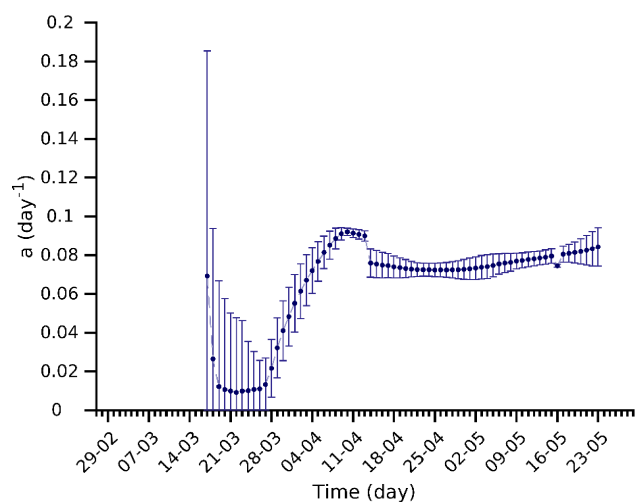
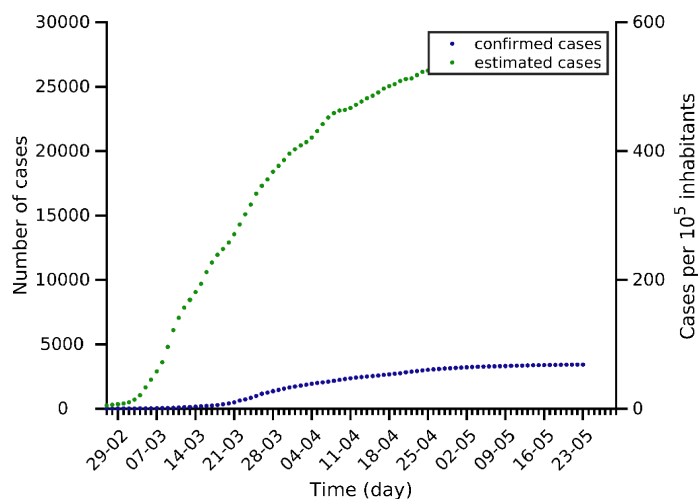
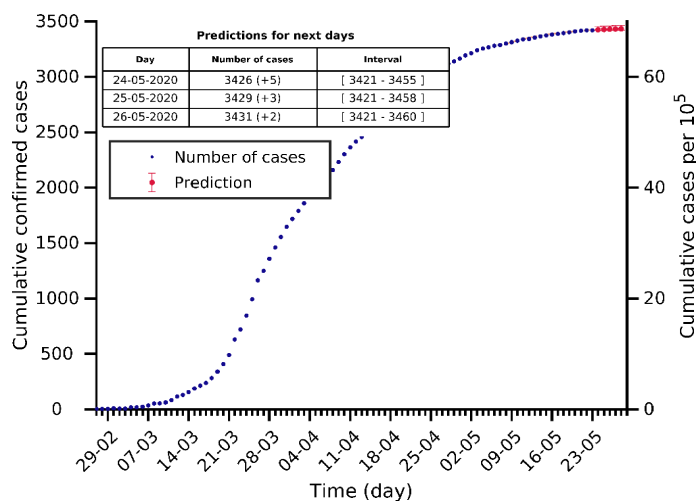
Puglia 23-05-2020. Population: 4.0M. Current cumulated incidence: 110/10⁵



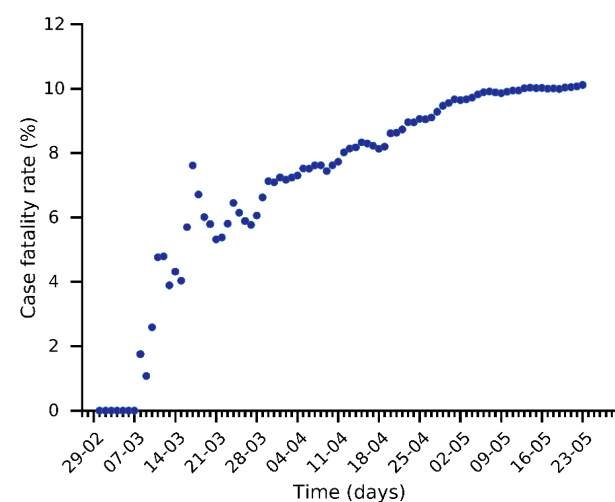
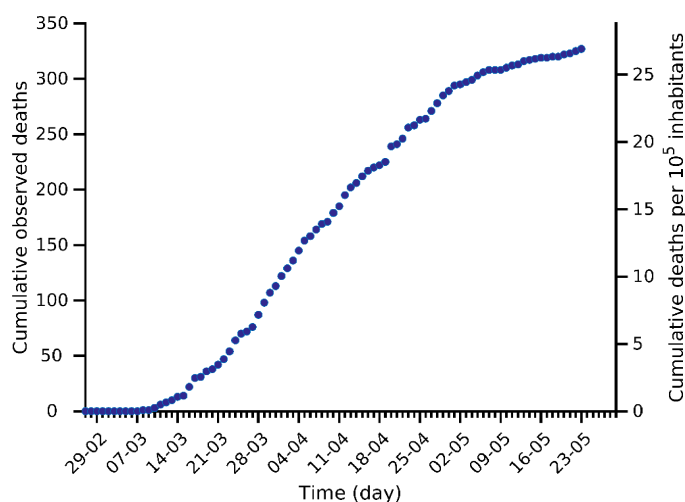
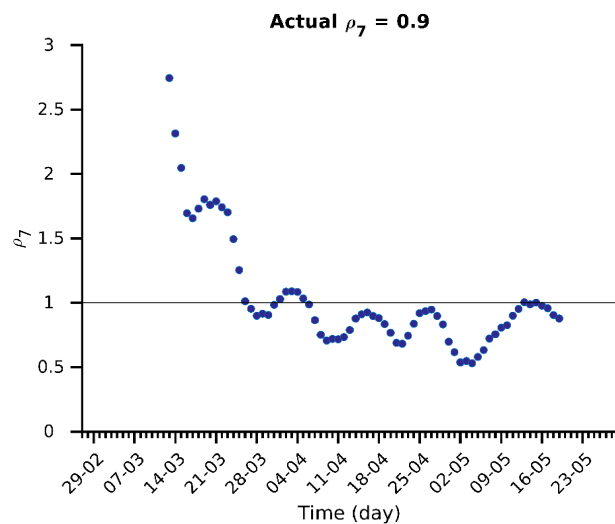
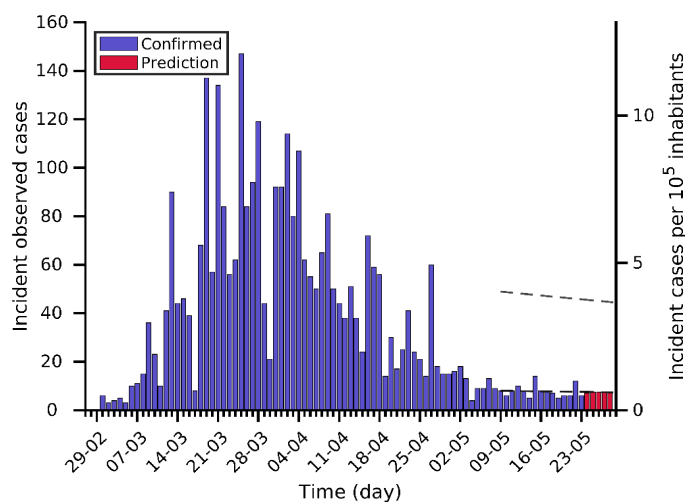
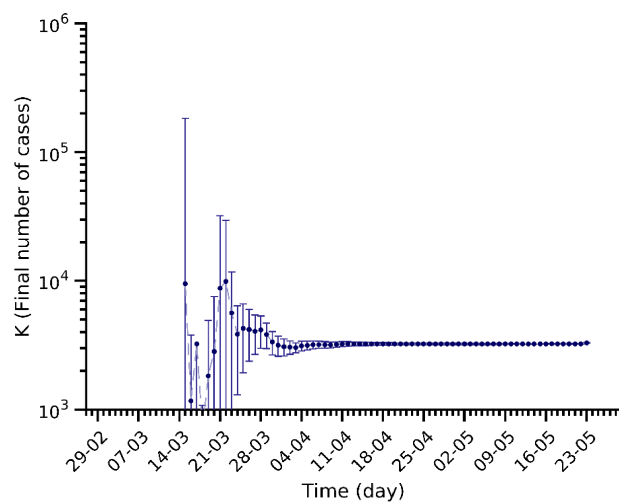
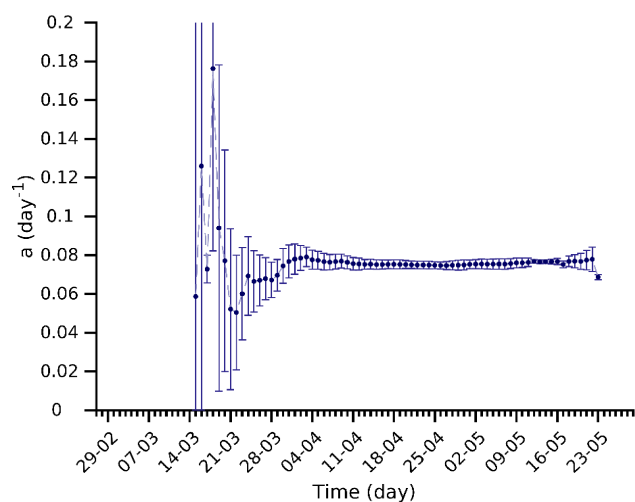
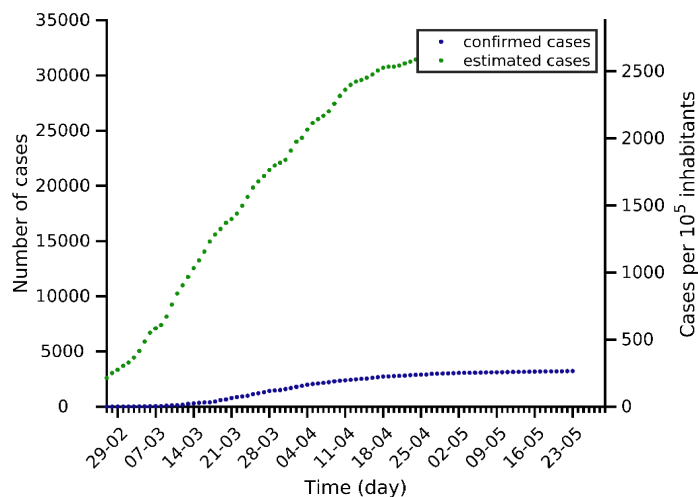
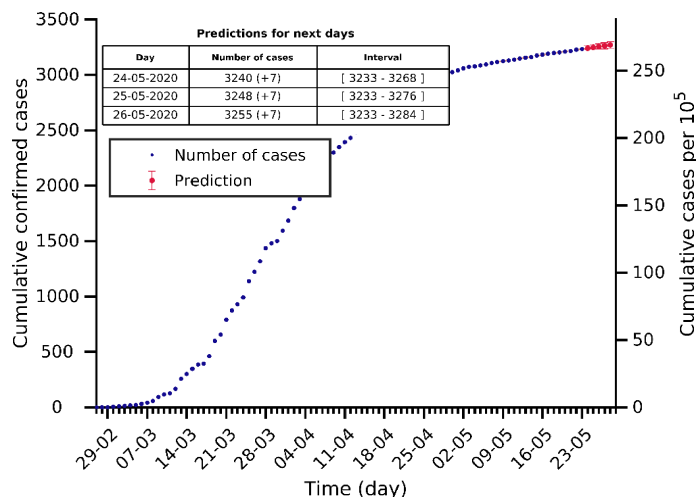
Trento 23-05-2020. Population: 0.5M. Current cumulated incidence: 817/10⁵



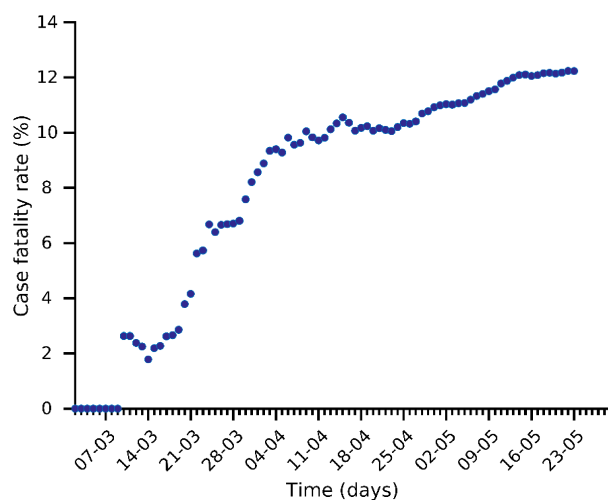
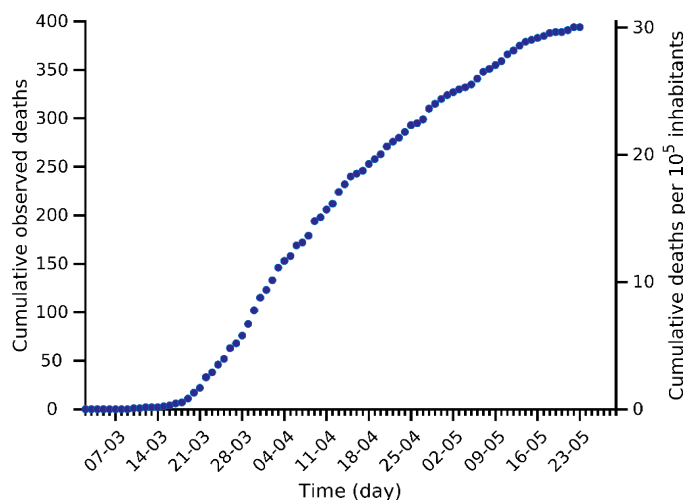
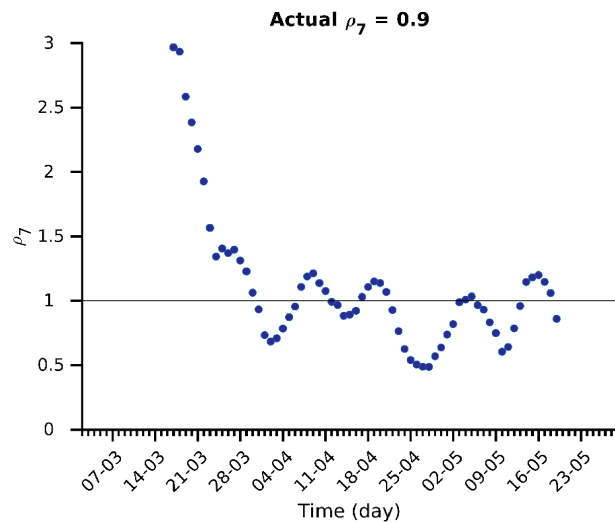
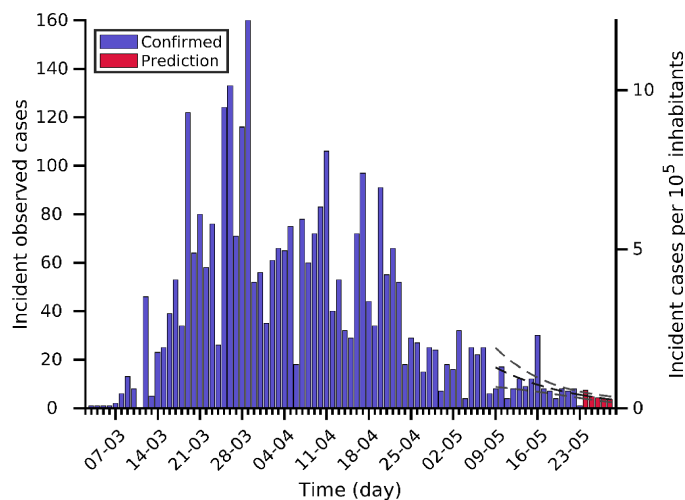
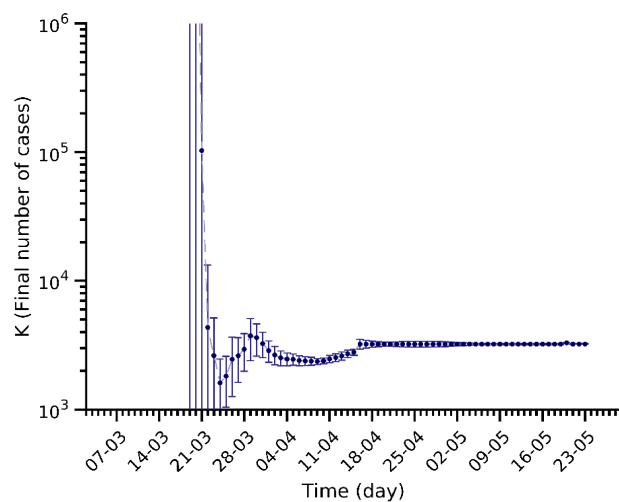
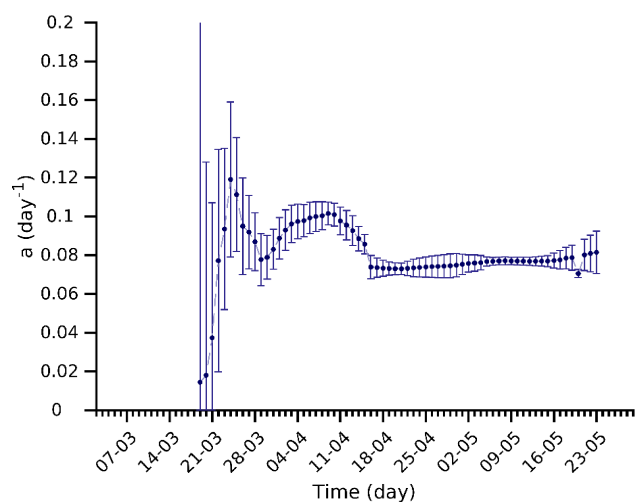
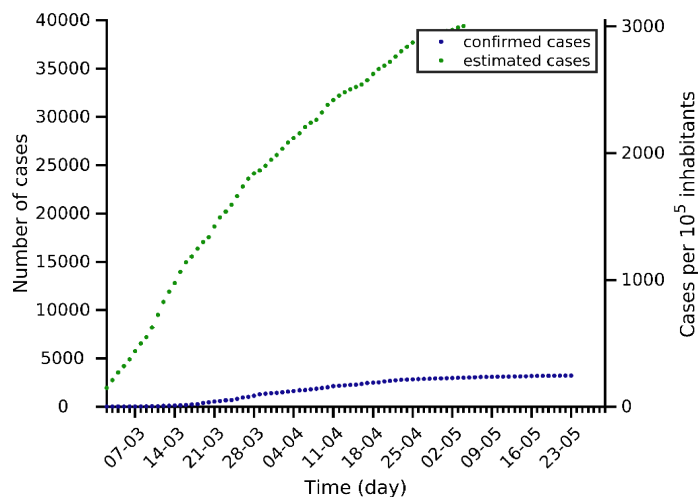
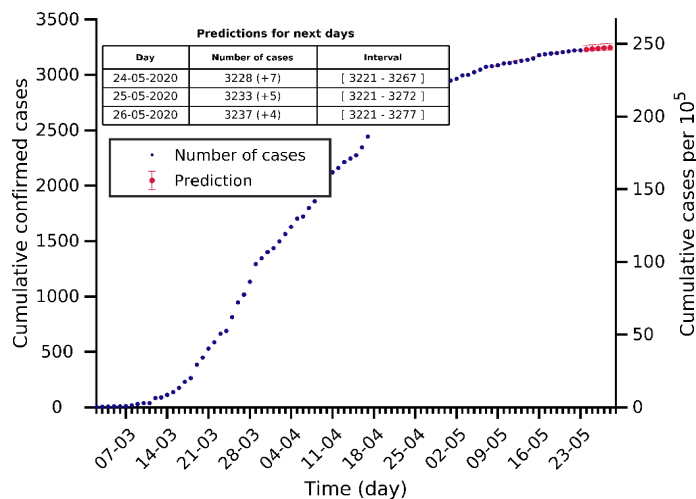
Sicilia 23-05-2020. Population: 5.0M. Current cumulated incidence: 68/10⁵



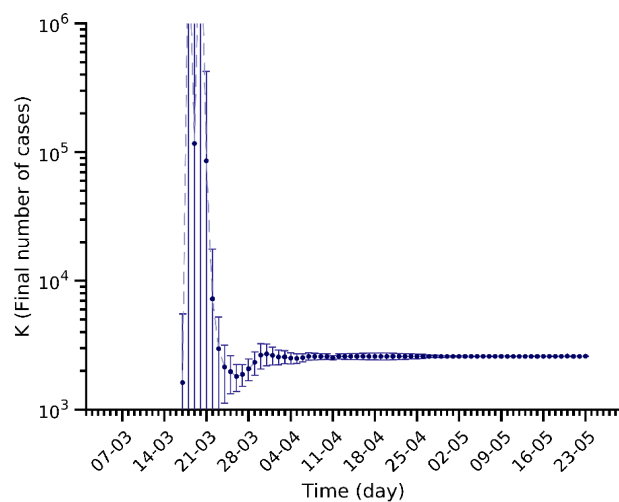
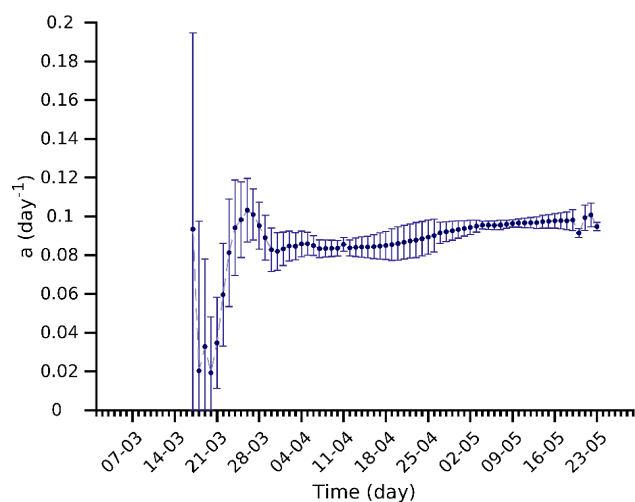
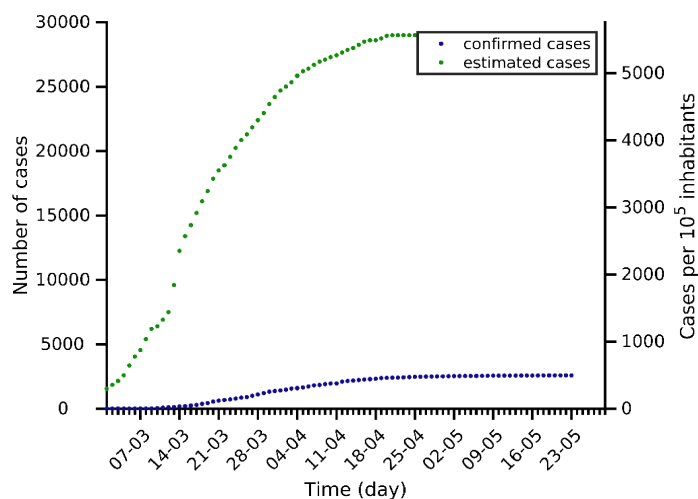
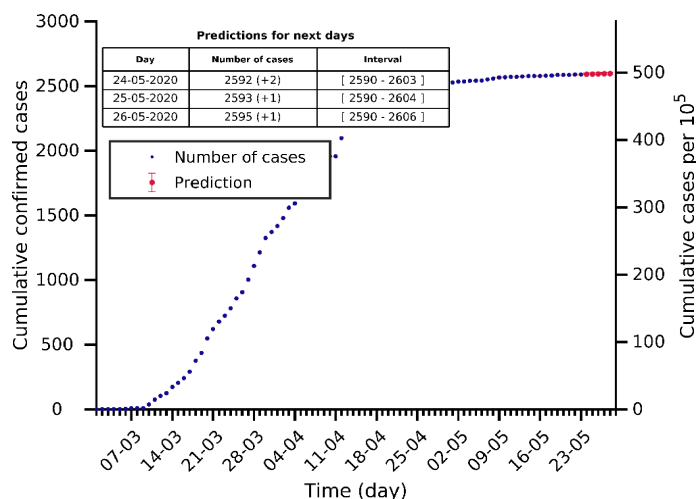
Friuli Venezia Giulia 23-05-2020. Population: 1.2M. Current cumulated incidence: 2



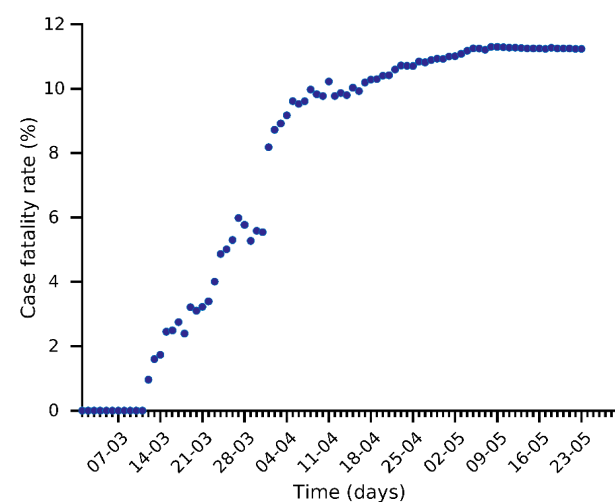
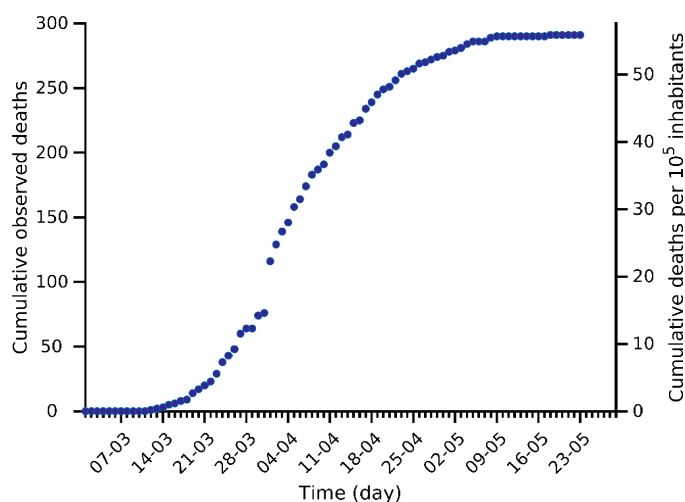
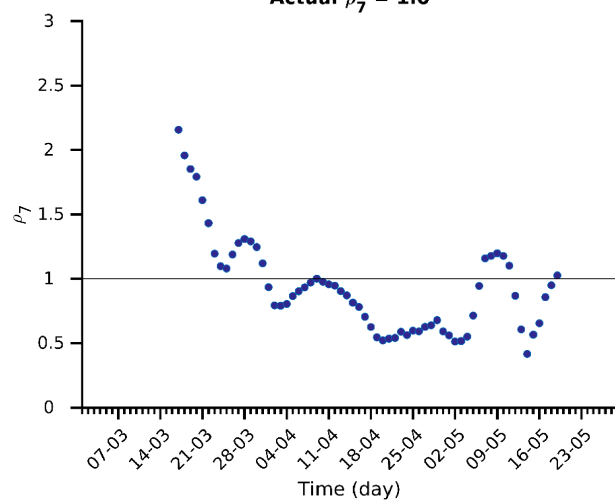
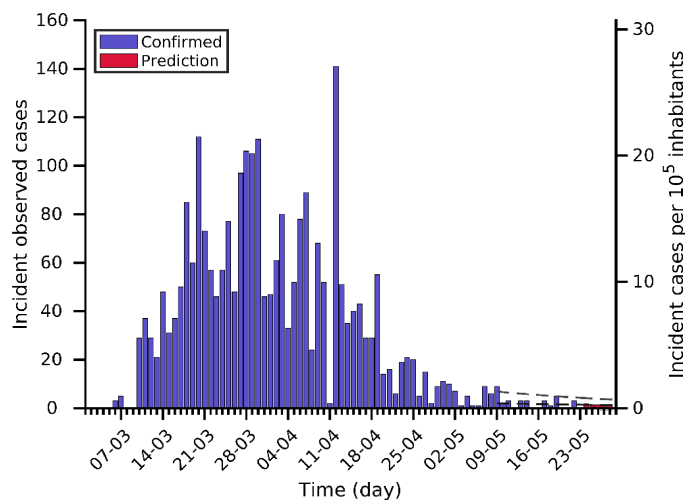
Abruzzo 23-05-2020. Population: 1.3M. Current cumulated incidence: 246/10⁵



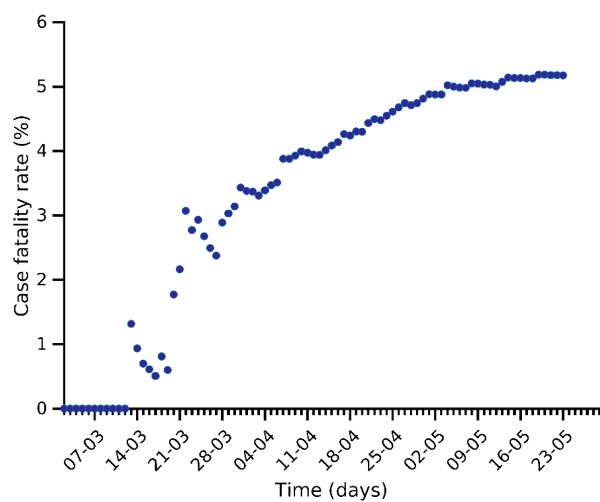
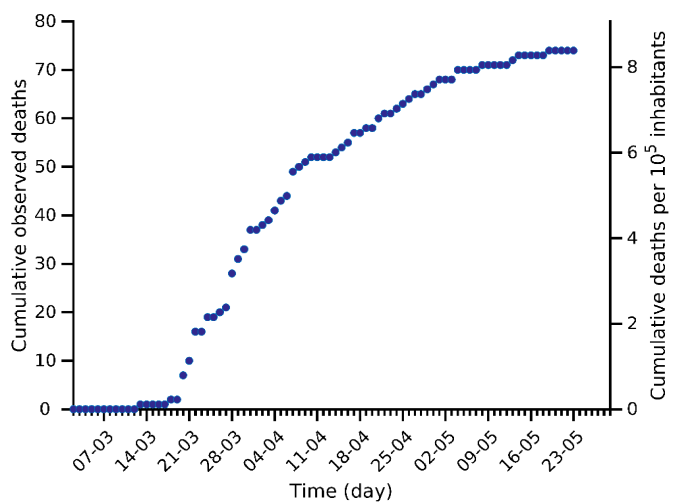
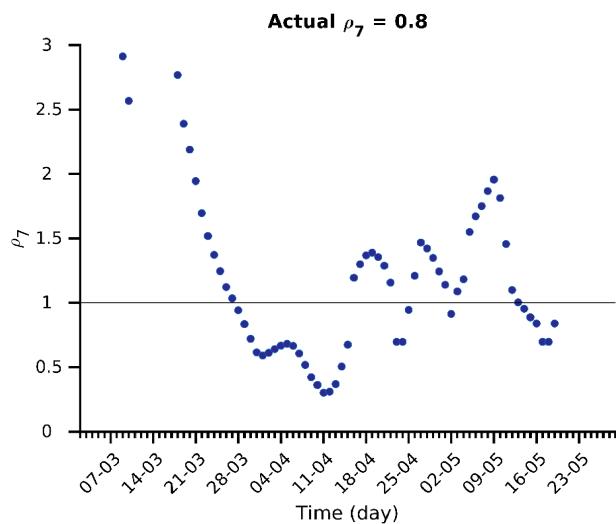
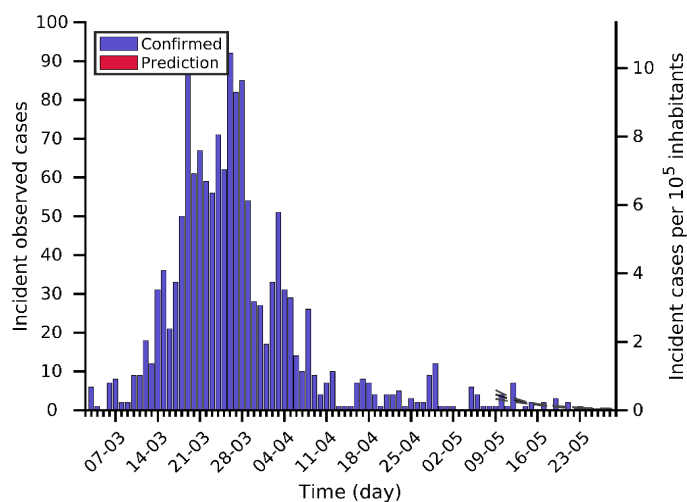
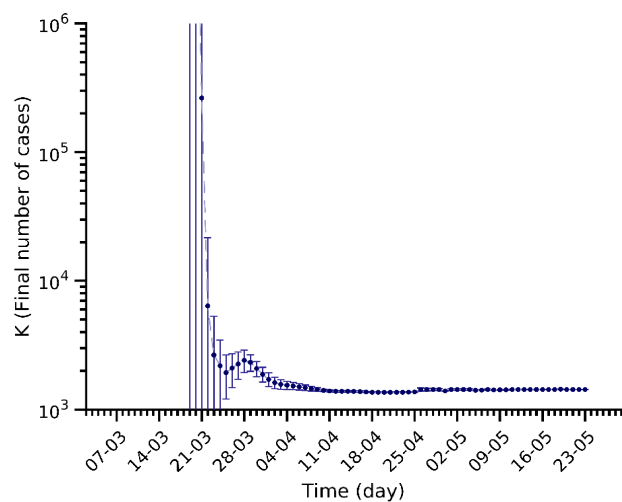
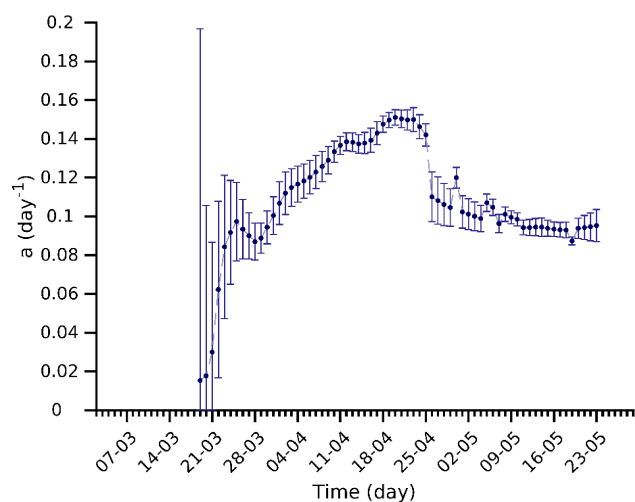
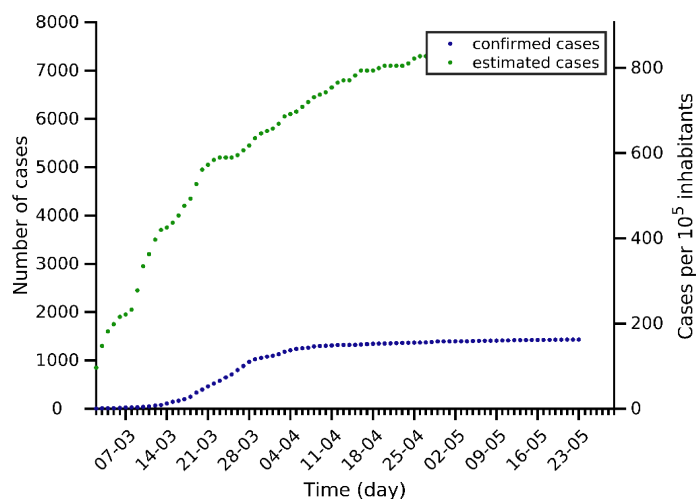
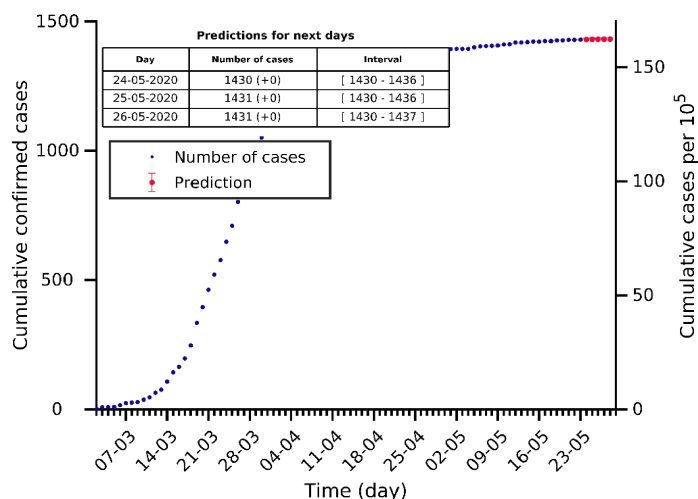
Bolzano 23-05-2020. Population: 0.5M. Current cumulated incidence: 497/10⁵



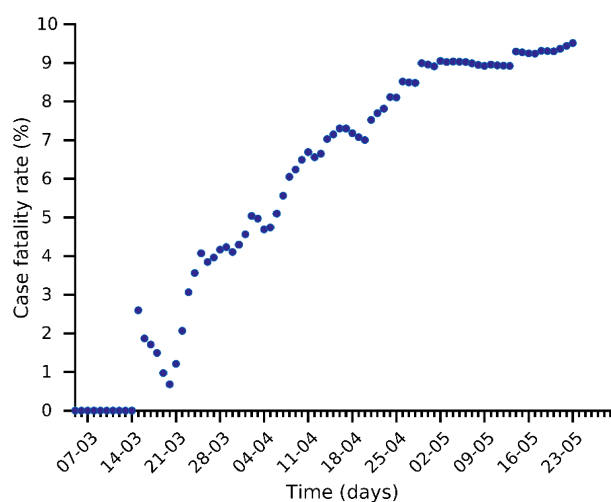
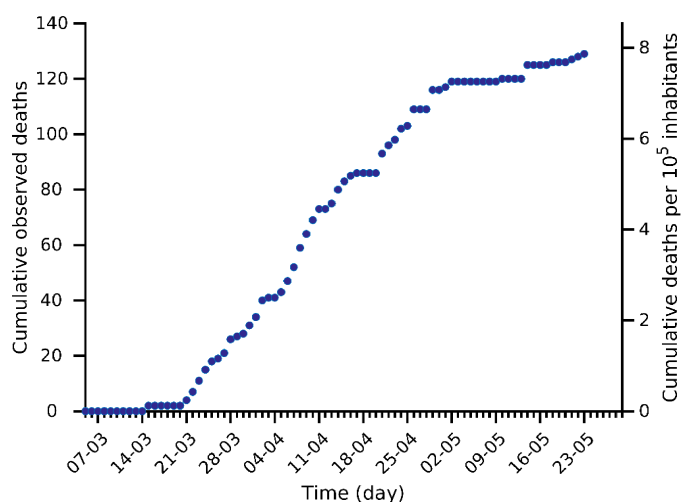
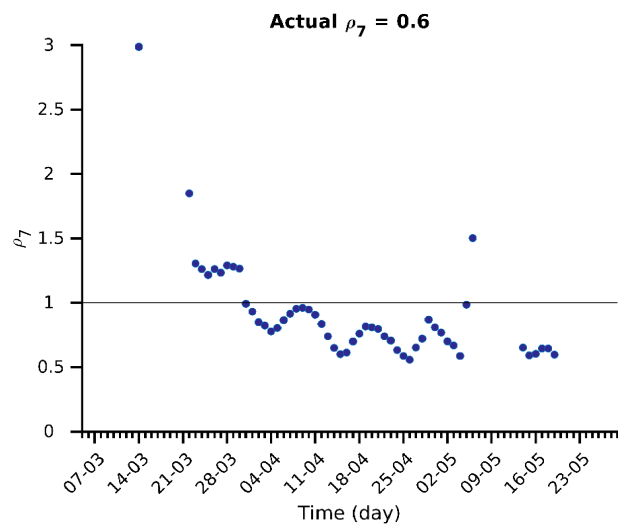
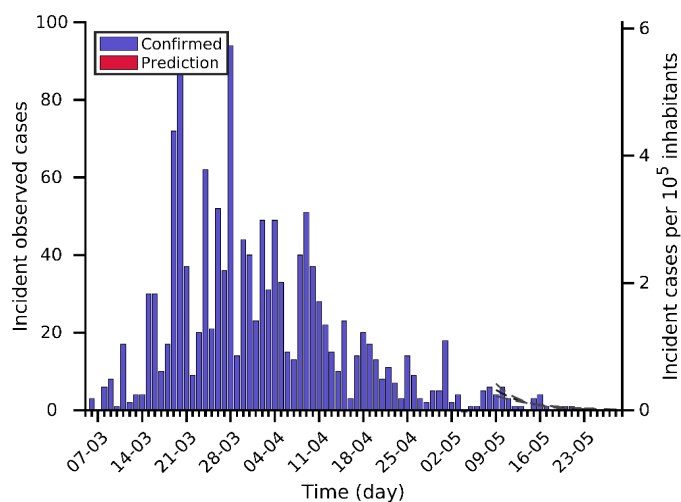
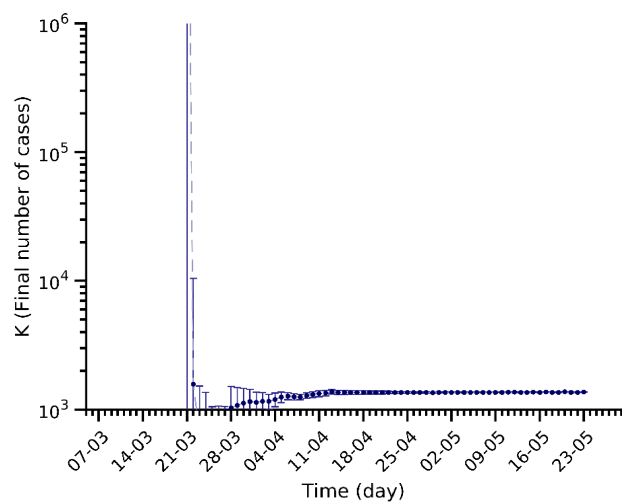
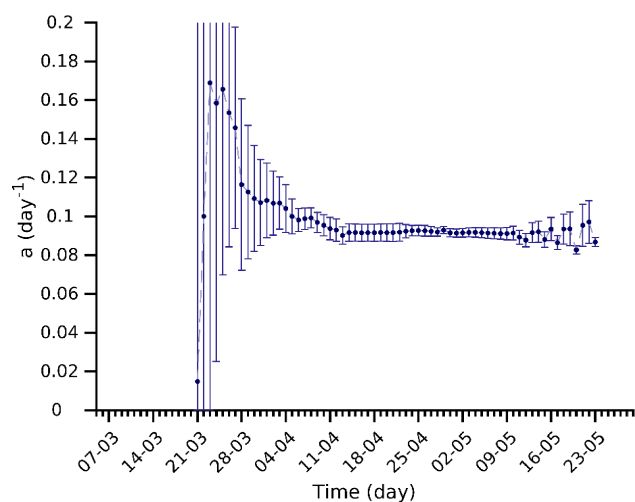
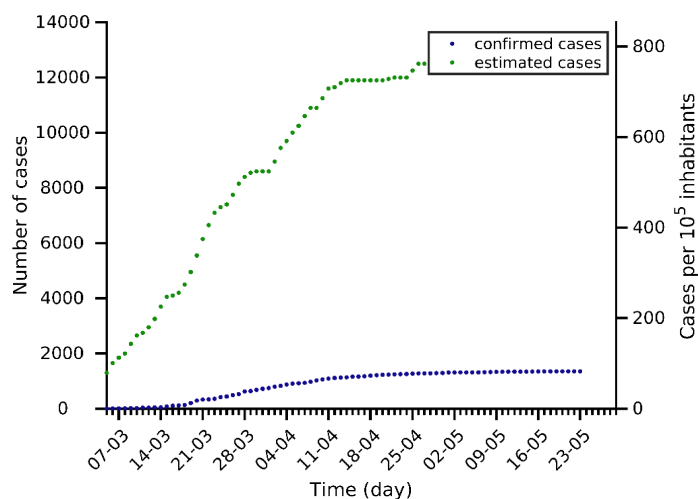
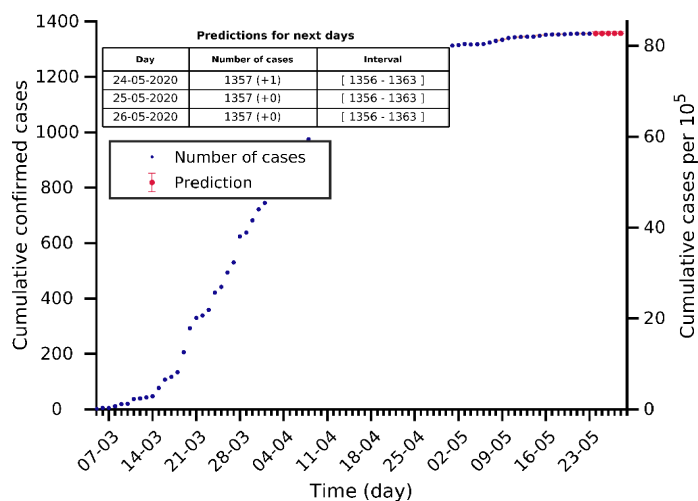
Actual $\rho_7 = 1.0$



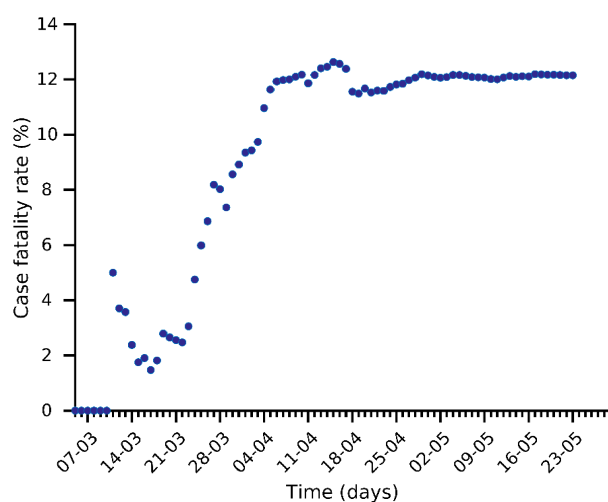
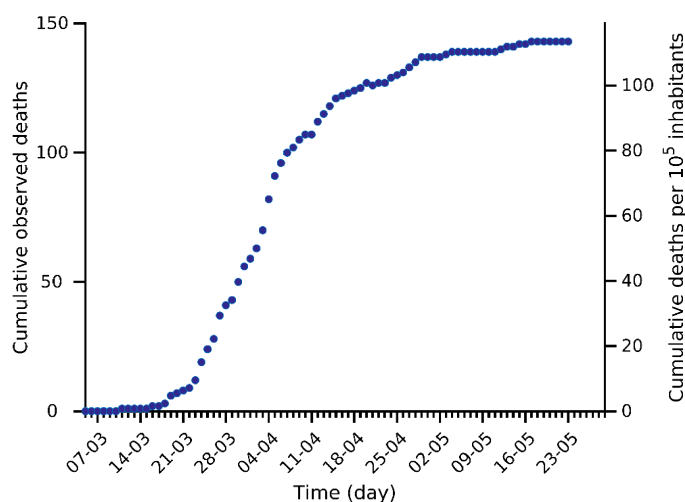
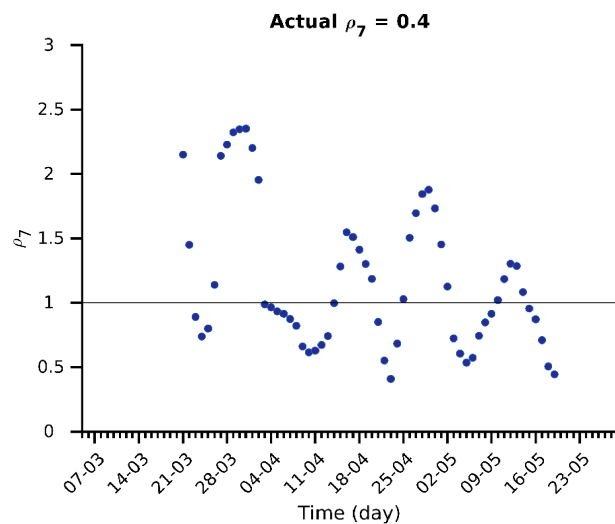
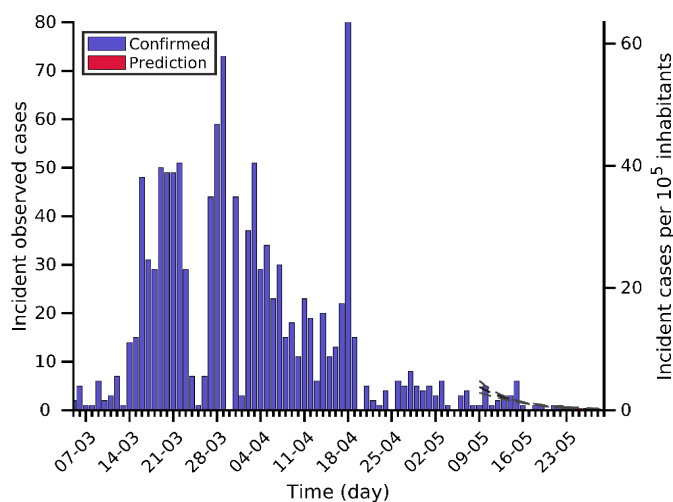
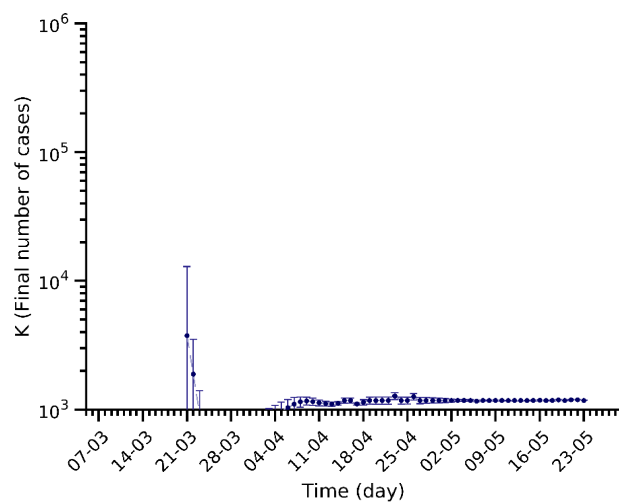
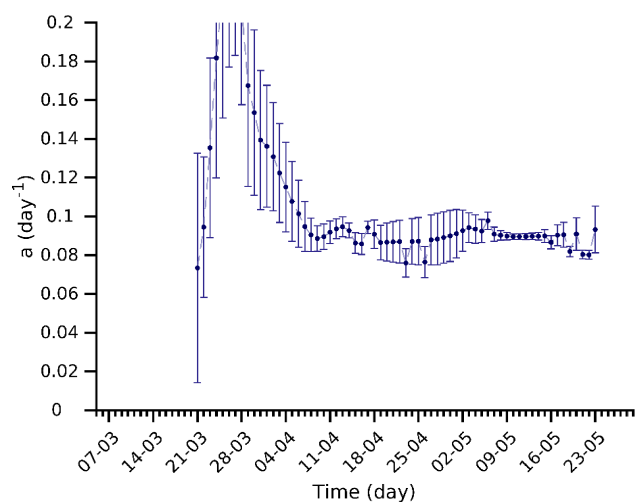
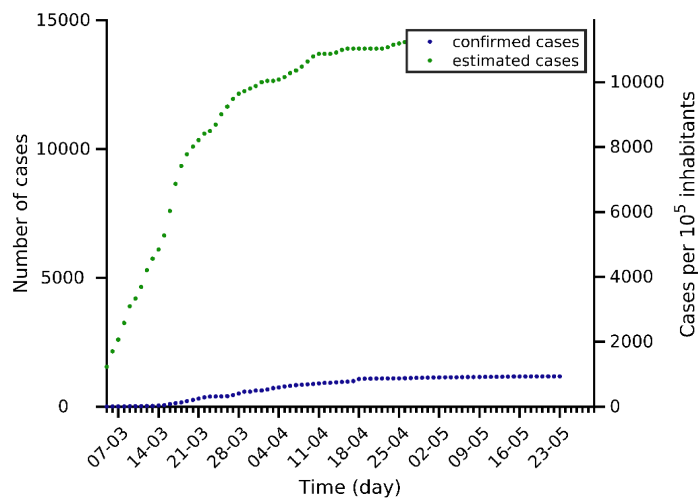
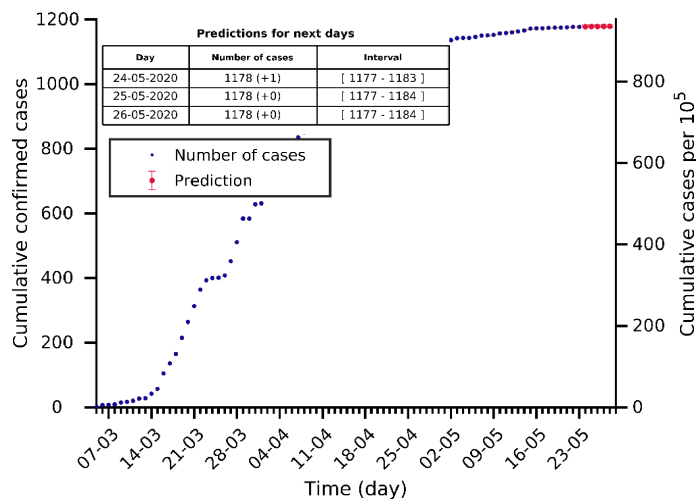
Umbria 23-05-2020. Population: 0.9M. Current cumulated incidence: 162/10⁵



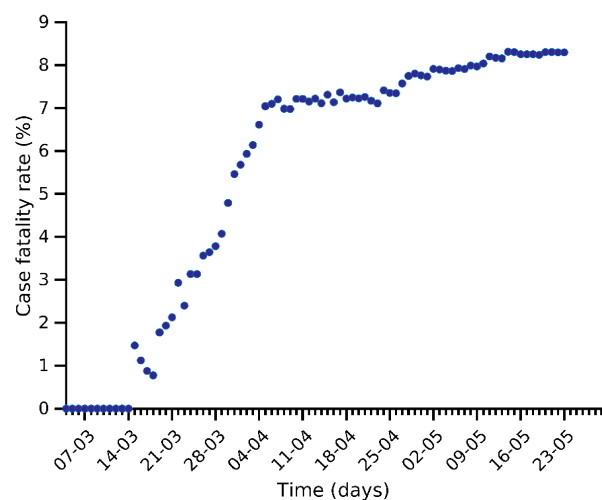
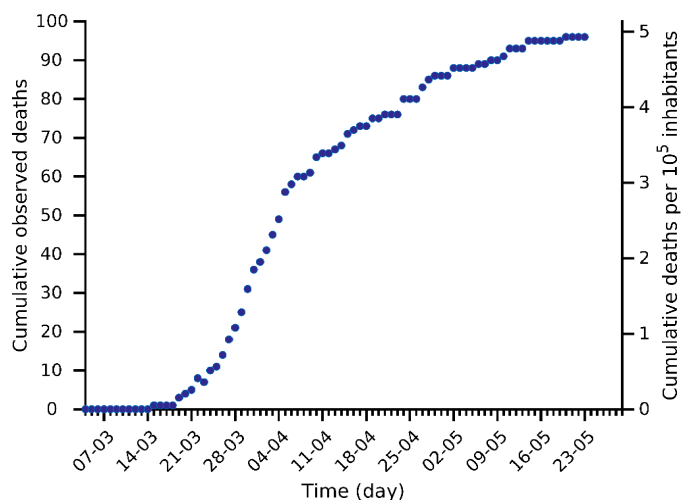
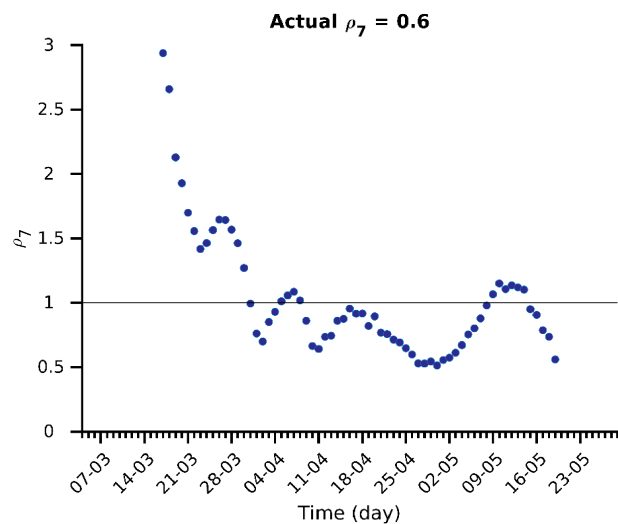
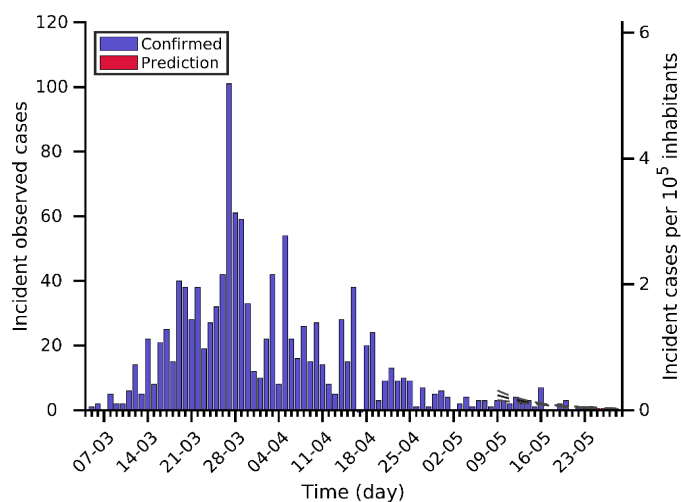
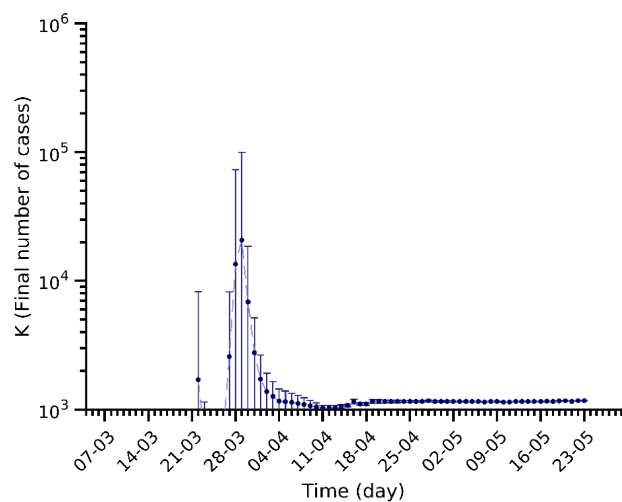
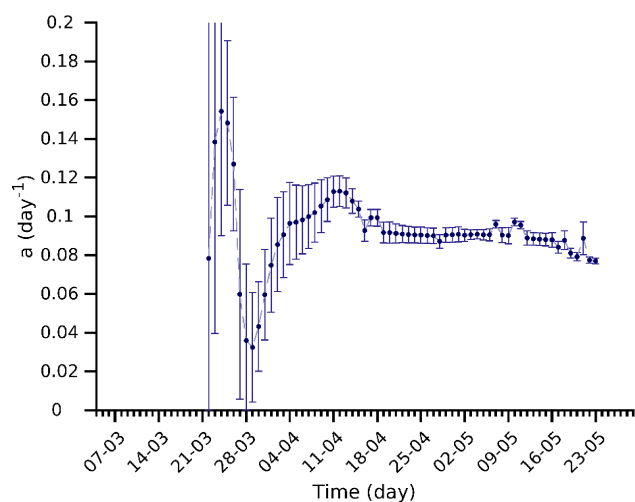
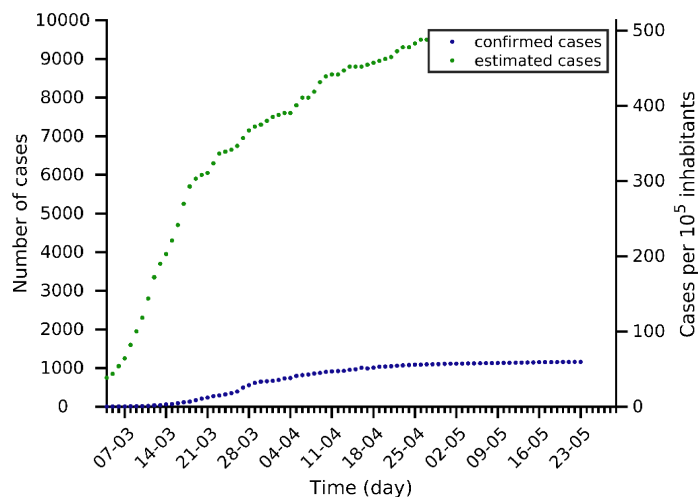
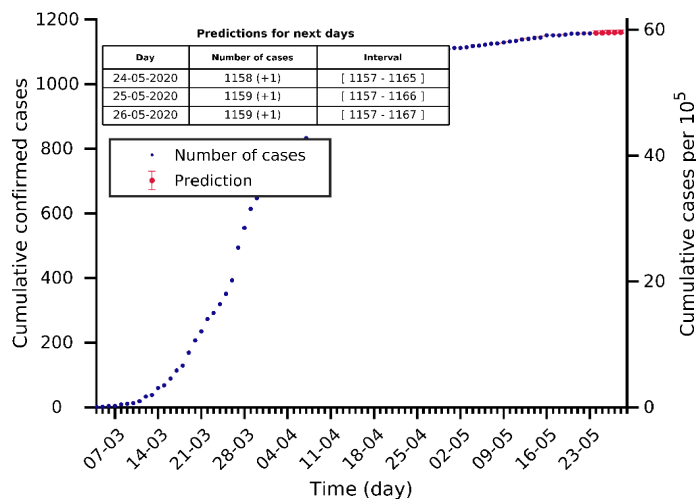
Sardegna 23-05-2020. Population: 1.6M. Current cumulated incidence: 83/10⁵



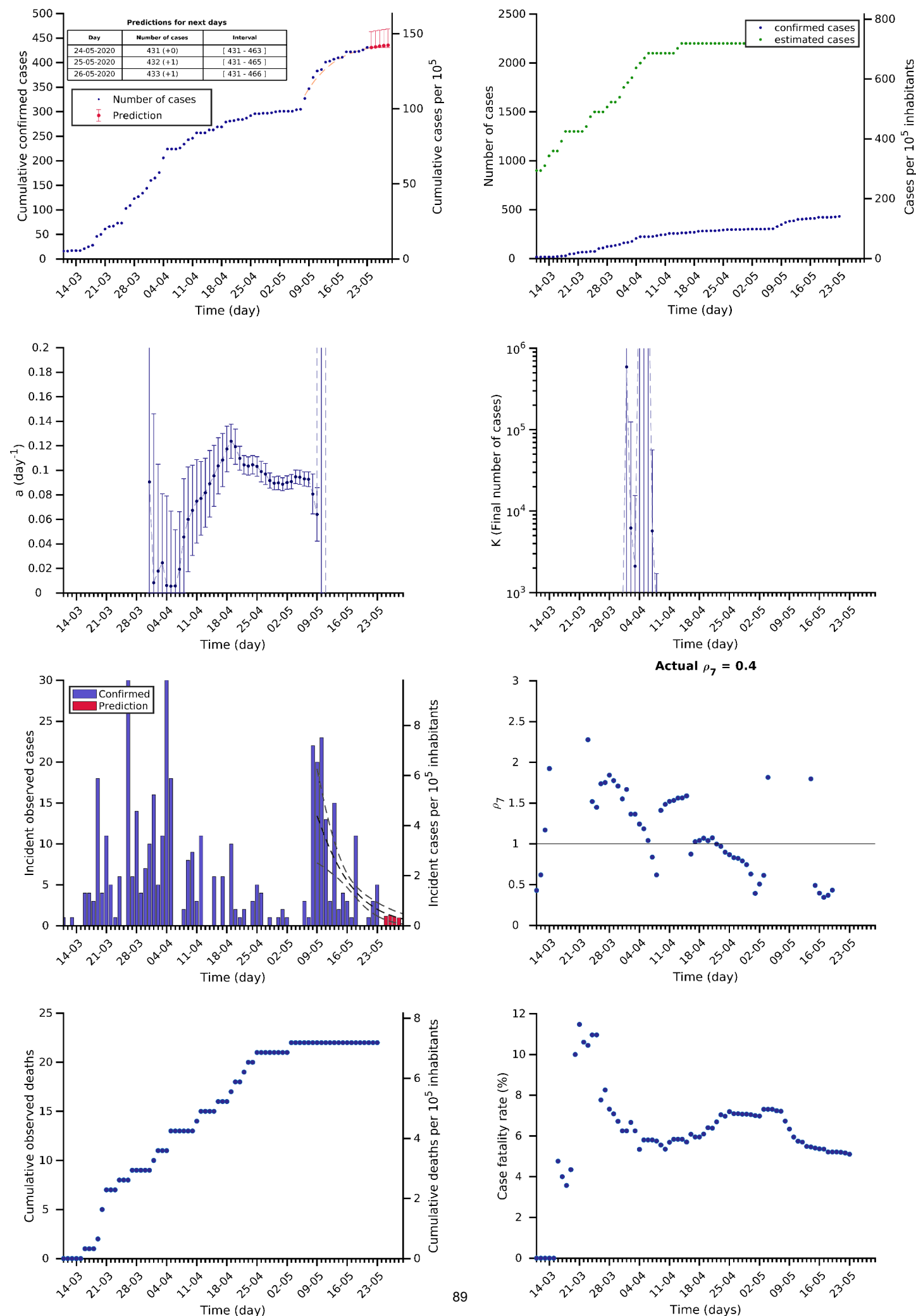
Valle d'Aosta 23-05-2020. Population: 0.1M. Current cumulated incidence: 934/10⁵



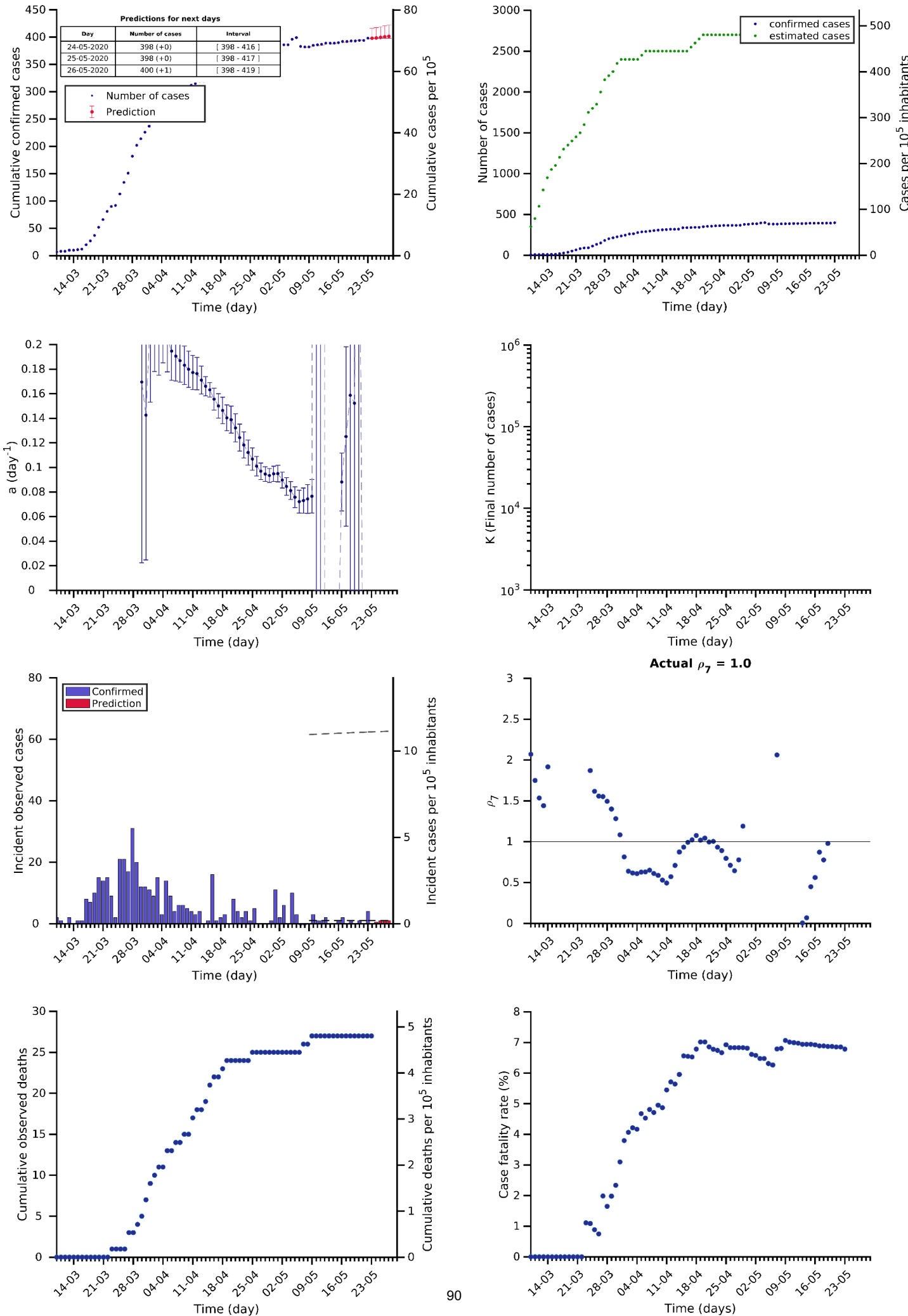
Calabria 23-05-2020. Population: 1.9M. Current cumulated incidence: 59/10⁵



Molise 23-05-2020. Population: 0.3M. Current cumulated incidence: 141/10⁵



Basilicata 23-05-2020. Population: 0.6M. Current cumulated incidence: 71/10⁵



Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports², from European Centre for Disease Prevention and Control (ECDC)³ and from Ministerio de Sanidad⁴. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ : this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report ($t-1$):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t .

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

- (I) an initial period where most of the cases are imported;
- (II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

² <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

³ <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

⁴ <https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>
<https://github.com/datadista/datasets/tree/master/COVID%2019> , <https://covid19.isciii.es/>

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model⁵ correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K e^{-\ln\left(\frac{K}{N_0}\right) \cdot e^{-a \cdot (t-t_0)}}$$

where $N(t)$ is the cumulated number of confirmed cases at t (in days), and N_0 is the number of cumulated cases the day at day t_0 . The model has two parameters:

- ✓ a is the velocity at which specific spreading rate is slowing down;
- ✓ K is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which $N(t)$ overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (a and K) and the R^2 of the fitting. At the initial stages the dynamics is exponential and K cannot be correctly evaluated. In fact, at this stage the most relevant parameter is a . Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted a with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted K with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a > 0.2 \text{ day}^{-1}$, if $K > 10^6$ or if the error in K overpasses 10^6 .

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

⁵ Madden LV. Quantification of disease progression. Protection Ecology 1980; **2**: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days⁶;
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors⁷ in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

⁶ At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

⁷ Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3